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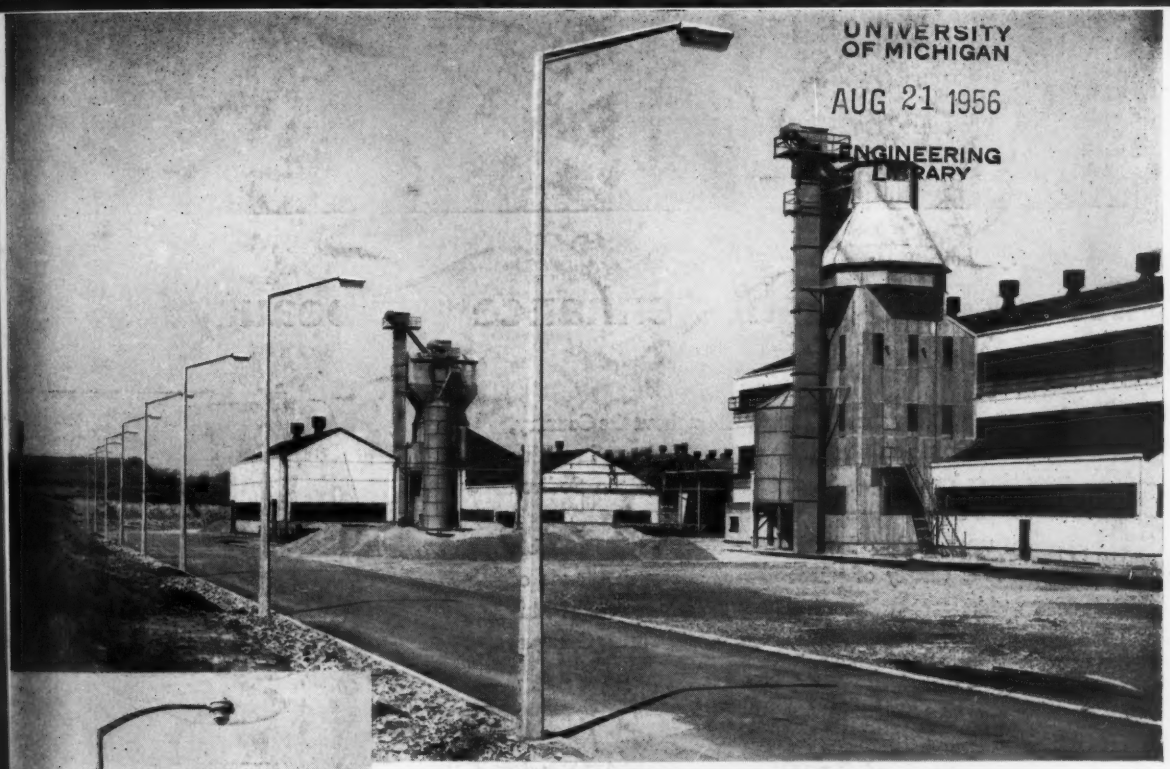

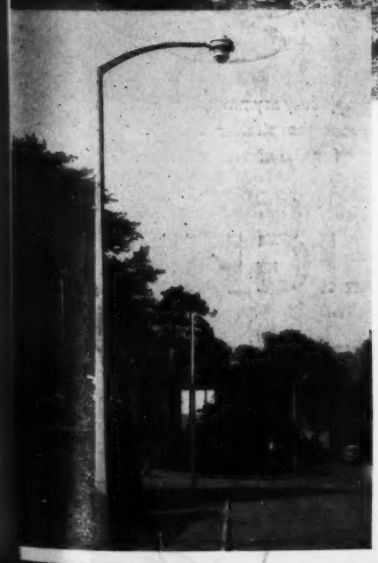

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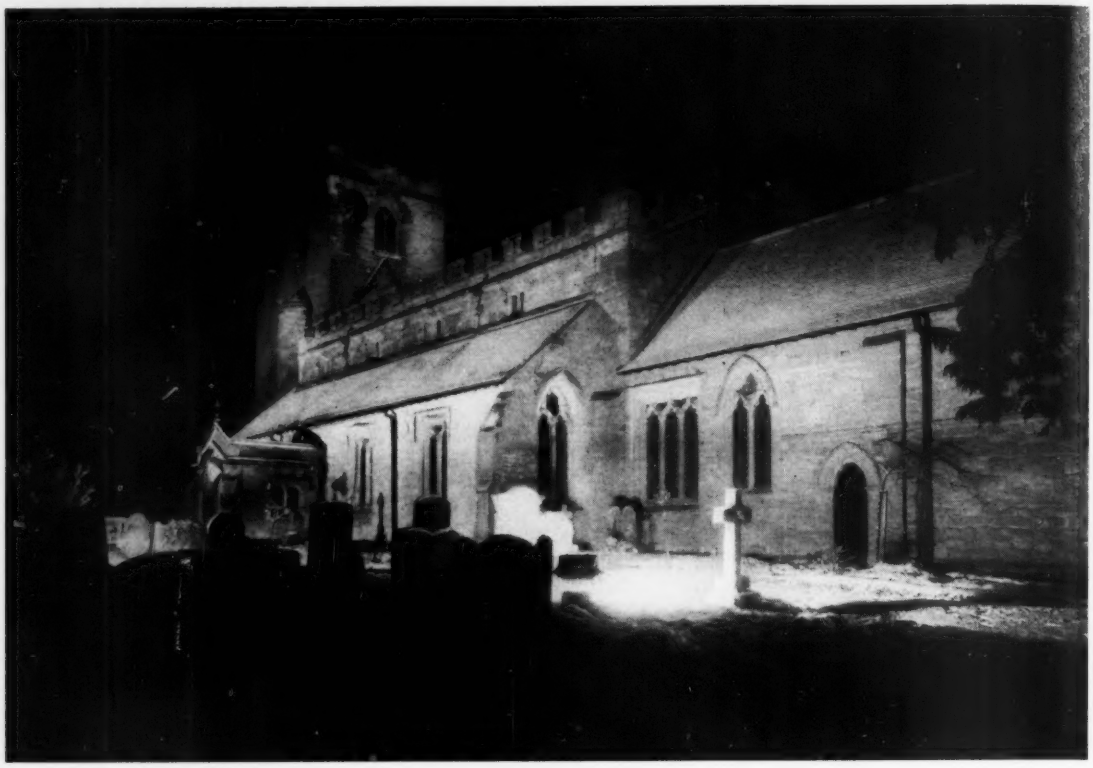

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Light and LIGHTING

Vol. 49. No. 8. August, 1956

Published by The Illuminating Engineering Publishing Co. Ltd. on the 1st of each month at 32, Victoria Street, London, S.W.1. Telephone: ABBey 7553. - Subscription rate 25s. per annum.

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Filament or Fluorescent?

WHICH of these types of lamp gives the best illuminant for clerical work? To find an answer to this question a carefully planned investigation has been made which is the subject of an article we publish this month. The investigation afforded no evidence that the performance of the persons studied at clerical work differed significantly with the alternative illuminants when each provided a standard illumination of 12 lumens per square foot. This finding agrees with that of other investigators who previously reported that, so far as visual acuity is concerned, various "near white" lights—including tungsten and fluorescent—are equally satisfactory. It thus appears that for clerical work, and probably for work of most other kinds, the choice between tungsten and fluorescent lighting can be made on other considerations than that of visual performance. Economic, engineering and aesthetic considerations may all affect the choice, but, whichever way it goes in particular cases, good lighting can always be had by modern light sources skilfully applied.

Notes and News

THIS year's Exhibition of Scientific Instruments, organised by the Physical Society, had several features which made it of more than usual interest to those anxious to keep themselves abreast of progress in matters closely connected with lighting and with colour.

Perhaps the most striking was an admirable series of exhibits arranged by the Colour Group to demonstrate the basic principles underlying colour television. Starting with a demonstration of additive colour mixture, the first section of the display showed how a coloured picture could be produced by superposing three component pictures, one in each of the colours red, green and blue; the analogy between vision by the eye and colour television was then explained. Next came exhibits showing the principle of the television camera and the way in which the image could be translated into three video signals, one corresponding to each colour. These signals are used to build up a coloured picture in a special kind of cathode ray tube called a Lawrence tube, and how this is done was explained by means of an ingenious model in which a " point source " of light was used to simulate the source of electrons in the tube. In the final group of exhibits there was one which showed very convincingly that the brightness (or luminance) component of a picture was much more important than its corresponding colour (or chrominance) component in determining acceptability by the average observer.

Among the other exhibits of interest to the lighting engineer there was a brightness meter (or, more properly, a luminance meter) developed by the BTH Company for measuring the luminance of a small patch of road surface *in situ*. The range was from 0.01 to 1 ft.-lambert. For users of modern detergents there was a fluorescent light meter which could tell them how much " brightness " was added to the " whiteness " produced by their favourite brand of powder. There were, as usual, a number of photoelectric photometers designed for different types of light measurement. Philips Electrical showed their colour-matching unit designed to give an illumination of 80 lm/ft^2 over quite a large area. The light from six 40-watt 4-ft. fluorescent lamps was blended in the unit so that the resulting colour approximated to north skylight with a colour temperature of about 10,000 deg. K. Bellingham and Stanley had on their stand a model of the six-stimulus type of colorimeter designed by Donaldson at the N.P.L., while Tintometer, Ltd., showed a production model of a new design of Lovibond-Schofield Tintometer.

Prof. Ditchburn and a number of research workers at Reading University had an interesting exhibit showing not only a method of recording small rotations of the eyeball, but also a device by means of which it was possible to produce an image which remained continuously on the same spot of the retina in spite of spontaneous movements of the eye.

Among the exhibits from the GEC research laboratories there was a tungsten lamp which gave pink light, although the bulb was uncoloured. The colour was due to a small amount of iodine vapour introduced into the bulb. Lest any reader should worry his local supplier for this latest novelty, we ought to add that the description in the catalogue was accompanied by the words " Not in production."

The lamp was referred to by Mr. H. G. Jenkins during the course of the lecture he gave to a packed house on the first evening of the exhibition. Although his subject was advertised as " Recent Developments in Light Sources," the first part of the lecture was devoted to a description of the filament lamp and its development from the carbon days. Mr. Jenkins mentioned the search for a refractory material which could be used to produce a filament capable of running at a higher temperature than the tungsten filament in a gas-filled lamp, but he did not sound very hopeful. Turning to the discharge lamp, Mr. Jenkins said that the low-pressure mercury lamp emitted more than 60 per cent. of its total energy in the ultra-violet resonance lines, and it was the conversion of this u.v. energy into visible radiation by a suitable inorganic phosphor that was the basis of the modern fluorescent lamp. In the HPMV lamp the resonance radiation was lost by self-absorption and the lines in the visible spectrum were greatly enhanced. The sodium vapour lamp was a resonance radiation emitter, giving practically all its light in the yellow resonance lines so familiar in the sodium flame. It was due to the fact that these lines occurred in a part of the spectrum where the sensitivity of the eye was high that the sodium lamp was so efficient. Returning to the fluorescent lamp, Mr. Jenkins mentioned that it was possible to increase the loading by departing from the usual form of tube with a circular section; a kidney-shaped section had been used at a loading of 25 watts per foot run instead of the 16 in the familiar 5-ft. lamp. The lecture was very well illustrated with slides and demonstrations.

As from October 1 the price per copy of *Light and Lighting* will be 2s. 6d. and the annual subscription will be 30s.

Suspended stairs in the engine research building at the new Technical Centre of General Motors at Warren, Michigan. The Wakefield Sigma-Plex 5 ft. module multi-functional ceiling is shown.

C

Tunnel Lighting and Specular Reflection

By A. J. HARRIS, B.Sc.*

It is suggested that specular reflection from the glazed surfaces of tunnel walls could be used to enhance their brightness. At present this possibility appears to be neglected. The lighting of vehicular tunnels is examined, in principle, from this point of view.

The lighting of tunnels presents many problems, a number of which arise from the difficulty of getting a high wall-brightness without heavy expenditure on lighting. Modern developments have recently been described by Waldram.† It is somewhat remarkable, however, that there has apparently been little or no attempt to use specular reflection for increasing the brightness of the tunnel walls. How, in principle, this might be done is described in this article in the hope of interesting those who may one day have the task of constructing and then lighting one of these tunnels. Problems of construction are not considered; the practical difficulties must be examined by those who are competent to discuss them.

Suitability of Tunnels for Exploiting Specular Reflection

Tunnels are frequently lined with glazed bricks or tiles. These are generally white to reflect as much light as possible and thus increase the brightness of multiple reflection. These glazed surfaces are also capable of extremely good specular reflection, but no use appears to be made of this property. As one looks towards the end of a tunnel from the inside one may see that light from the sky, or from buildings illuminated by the daylight outside, is being reflected specularly at the walls, so that these have a high brightness even at a great distance from the opening. As a rule this reflection of the daylight does not appear particularly valuable because, although the length of wall brightened in this way may be large, it looks insignificant in perspective unless the end of the tunnel is fairly near. Occasionally, when the tunnel has a bend to one side, the effect is much more impressive. Specular reflection from lights within the tunnel is less often seen, but, because the reflection of isolated sources takes the form of long curved bright streaks, it is usually considered to be a nuisance. If, however, the source of light were continuous, as in some more modern tunnels, this disadvantage would not occur and specular reflection could be turned to good account.‡

A tunnel offers peculiarly favourable opportunities for exploiting specular reflection for the benefit of vehicular traffic. A vehicle must usually remain in the same traffic lane during its passage through the tunnel, and therefore the area of the tunnel cross-section which may be occupied by a driver's eyes is quite small. Lorry drivers' heads are not more than about 3 ft. higher than those of car drivers, and the side to side variations are perhaps even smaller. To concentrate the specularly reflected light into this restricted area will therefore increase the apparent brightness of the walls as seen by the drivers. This can be done by choosing the shape of the walls and the position of the light source.

A Simple Example

As a first example the simplest ideal case may be considered: a long, straight, single-lane tunnel, as shown in Fig. 1. The cross-section is elliptical with foci at A and A′. The driver's eye is on the axis through A, and the light is a line source on the axis through A′. In this case, if the walls were perfectly reflecting the driver would see the entire surface flashed to the brightness of the source. With glazed bricks the brightness would, of course, be less, but it would still be high in comparison with that due to diffuse reflection.

The principle involved is to use a line source so placed that the driver's eye moves along the image of the source. It should perhaps be pointed out here that there is no image as we normally understand it: light radiating from a single point on the A′ axis in Fig. 1 does not return to a single point on the A axis. Nevertheless, any ray from A′ will pass through the A axis after reflection.

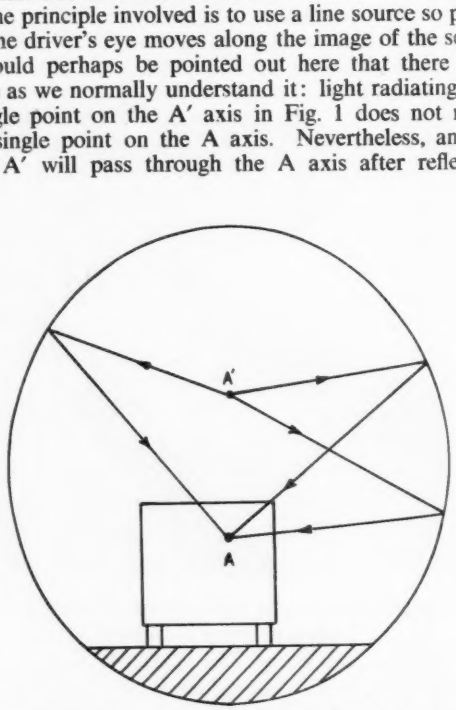

Fig. 1. Elliptical tunnel for idealised single-vehicle lane. A and A′ foci of the ellipse.

* The author is with the Road Research Laboratory, Department of Scientific and Industrial Research.

† Waldram, J. M. The Lighting of Tunnels. *Light and Lighting*, **49** (2), 51-56 (1956).

‡ Since this was written the author has seen the lighting in the Blackwall Tunnel. Specular reflection much in evidence, both from the artificial light sources and from the daylight at the end.

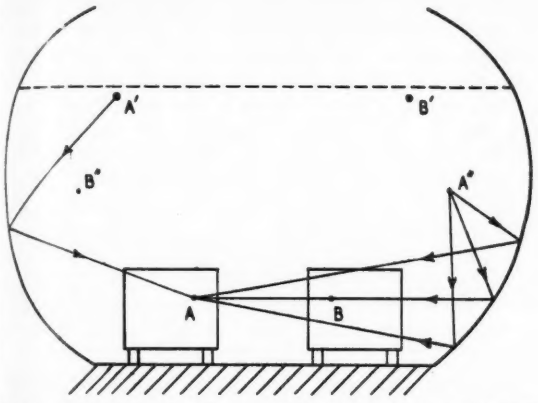

Fig. 2. Two-lane tunnel. A and A′ are foci of left-hand ellipse. B and B′ of right-hand ellipse. A″ and B″ are points such that rays from A″, for example, pass approximately through A after reflection at the lower part of the wall.

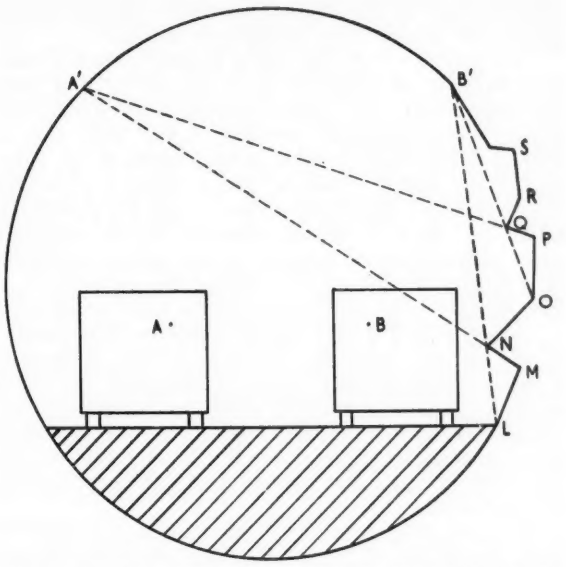

Fig. 3. Circular tunnel with modified outline. LM, OP, RS, etc., reflect from A′ to A and B. NO, QR, etc., reflect from B′ to A and B. Each of these elements may have to be divided into two bands, one to reflect to A, one to B.

Similarly, in whatever direction an eye at A may be looking, the line of sight, if carried backwards, reflected in the wall and then prolonged, will ultimately pass through the A′ axis. Thus in every direction there will appear an image of some part of the source. In fact, in treating the reflection of light within a cylindrical reflector the fact that the rays of light have a component of direction along the axis of the cylinder can be ignored. The reflections can be treated as if they were confined to the perpendicular cross-section. In this way the image of a source can easily be found and, provided it is remembered that the relationship between line source and line image is not quite the same as for the more usual point source and image, no difficulty occurs.

In a real tunnel too sharp an image is not desired, since a range of positions of a driver's eye has to be considered. For the same reason it is an advantage not to have too small a source. It is also no great disadvantage if the wall surfaces have a certain degree of small-scale imperfection of form, since this also will help to spread the light slightly. Indeed, if a narrow source such as the fluorescent tube is chosen for convenience, it may be desirable to line the walls with tiles whose surfaces are slightly ribbed in order to get the necessary spread of light.

More Elaborate Tunnels

In tunnels carrying traffic in both directions, the arrangement of tunnel shape and light sources is more complicated, for there are then a number of eye positions, each of which may require its own line source, or pair of line sources, to achieve the desired lighting of the walls. In Fig. 2, for instance, source A′ and the left-hand elliptical wall give specular reflection to A; B′ and the right-hand wall reflect to B. A second pair of sources A″ and B″ would probably suffice to brighten and lower part of the offside walls for A and B respectively. The reflection from these sources is less perfect than for A′ and B′, but by using a source of finite size it can be made adequate. As shown in Fig. 2, the roof of the tunnel is not included in the scheme, and might therefore pass close to A′ and B′ as indicated by the broken line.

The foregoing may give the impression that unless one is able to choose the overall cross-section of the tunnel to suit the lighting, nothing can really be done to utilise the specular reflection. This, however, is not true. Whatever the overall shape of the cross-section, specular reflection can still be obtained by adjusting the shape in detail. If the glazed surface of the walls is divided into horizontal bands having the appropriate slope, it will give the correct reflection, in the same way as prismatic glassware, while retaining an overall shape of slab or cylinder, can behave like a prism or a lens because of the shaping of the individual elements of the surface. The result in the tunnel may not be as effective as that obtained with a cross-section designed solely to achieve the best lighting, but in a multi-lane tunnel it is impossible to have a simple outline consisting of a single curve, and some composite form must be provided. The right-hand wall in Fig. 3 shows, in principle, how a circular two-lane tunnel might be treated to give reflection from both walls to each lane. The jagged outline is the result of trying to utilise as much of the surface as possible. The scale of this adjustment of the profile is, of course, arbitrary; for clarity it is shown relatively large in Fig. 3. It is an advantage if at least part of the light reaching the driver from each wall comes, as in Figs. 2 and 3, from a source whose illumination of that wall cannot be shaded by vehicles. In that case shadows cast by traffic cannot blot out the reflection entirely.

Tunnels with Bends, etc.

The principles as they have been explained here apply only to long, straight tunnels. Where there are bends or changes of vertical curvature, matters become more complicated. For instance, where a straight portion of a tunnel leads into a bend it will be impossible to continue the straight-line source required by the straight walls as far as is desirable. It seems likely, however, that specular

reflection can still be obtained provided a suitable tunnel shape and suitable light sources are chosen.

The way in which that end of a tunnel which is filled with daylight can brighten the walls just as if it were the appropriate line source extending indefinitely has already been described. Sources of this kind, that is, sources whose main extent is at right angles to the direction of the tunnel, would be useful where a prolonged line source was desired but where it was not possible to install it. Such a course, correctly placed, especially when viewed from a distance, is the partial equivalent of a length of line source. Where the equivalence is only required to be local, such a source might be effective.

Again, even if a light source cannot be used directly, it may be used indirectly. It may be used to brighten a specific area of wall which in turn will act as a secondary source of specular reflection. Even the horizontal curvature of the tunnel should not be neglected, since a judiciously chosen curve and suitable light sources may perhaps make it as easy to deal with bends as with straight portions.

The difficulties arising from curvature do not therefore seem insuperable. Clearly there are means of dealing with them, and indeed there appears to be great scope for ingenuity in this field.

Conclusion

The extent to which specular reflection can enhance the brightness of the walls depends very largely on the degree to which the light can be concentrated. Because the region which has to be filled with light is of the order of several square feet for each traffic lane, the improvement may not be as great as might be the case if all vehicles had their drivers' seats at the same height, but it may still be well worth obtaining. In many existing tunnels it appears that any light specularly reflected from the walls strikes the ground before it can reach the eyes of any driver, so that there is little experience of what specular reflection could do. One advantage of the use of this light, which is now wasted, would be that extra brightness would be obtained without increasing the total light in the tunnel and therefore without greatly increasing the veiling effect of any haze or fog which might be present.

It seems probable that the utilisation of specular reflection would have no effect on diffuse reflection, so that persons other than drivers would find the tunnel just as bright as if this special arrangement had not been adopted.

A restricted application of the principle might be to the raising of the brightness of the tunnel walls as seen by drivers approaching from the outside.

Acknowledgements

This paper is published by permission of the Director of Road Research.

Some Effects of Filament and Fluorescent Lighting on Visual Performance

By W. F. FLOYD,
B.Sc., Ph.D., F.Inst.P., A.M.I.E.E.*

There are two important differences between filament and fluorescent lighting: (i) a colour difference, and (ii) the presence of flicker with fluorescent lighting.

The colour of filament lighting is usually described as yellow, and is due to the paucity of blue in its spectrum. Fluorescent lamps are made in several types to give illumination of various colours: the "daylight" lamp gives a colour rendering akin to normal daylight; the "warm white" gives an effect more like that of the filament lamp, but different makes of "warm white" vary in their colour. More recently it has been possible with fluorescent lamps to simulate very closely the colour rendering of the ordinary tungsten filament lamp.

The flicker obtained with fluorescent lamps is due to the rhythmic extinction of the fluorescence which occurs under normal operating conditions, on a.c. mains, twice during each cycle of the mains supply, giving a flicker frequency of twice the supply mains frequency. The situation is rather more complex than this, however. Due to the occurrence of rectification in the discharge tubes the flicker from fluorescent lamps may contain an appreciable component at 50 per second, as was shown by Brett.

Flicker, even if not directly perceived, as at lower frequencies, may have its effect on physiological function. It has been claimed that the electroencephalogram is modified in some people during exposure to illumination containing a substantial flicker element, even at a frequency of 100/sec. The evidence, however, is slender. The flicker from filament lamps operated on 50 c/s. a.c. mains supplies is usually too small to be perceived or to have any physiological effects.

Experiments

Twenty-six subjects, 16 men, 10 women, took part in the first series of experiments. Landolt ring visual acuity performance tests (Weston) were given under the following lighting conditions: 6, 10 and 20 lumens per square foot derived from filament and fluorescent sources.

The successful completion of these tests depended on a

* Department of Physiology, Middlesex Hospital Medical School.
Summary of a paper presented at a meeting of the British Association for the Advancement of Science held at Bristol on September 7, 1955.

combination of sharpness of vision and the rapid cancellation of certain of the Landolt rings on the test sheet. The tests resembled clerical and fine clerical detail in visual difficulty, but called for no special ability otherwise. The test cards were of the single-ring type but of different contrasts, and the visual acuity demanded for the task was two, four or six minutes. Eyesight tests were carried out on all the subjects, and in the final statistical treatment of the results four subjects were omitted on account of defects of vision. The minimum visual standard accepted for the purpose of inclusion in the final results was 0.5 Snellen in one eye and 0.8 Snellen in the other. The subjects were also tested by the Maddox wing test for changes in ocular muscle balance.

There was no significant difference between the results obtained with fluorescent and filament lighting, and ocular muscle balance was unaffected throughout the tests.

In a second series of experiments the same subjects took part in tests involving the direct subjective equation of an adjustable level of fluorescent lighting with a fixed level of filament lighting. The subjects were exposed to alternate two-second periods of illumination from filament and fluorescent sources. A special lighting fitting was used which ensured approximately the same distribution of illumination from both sources, so that, on change over, there were no disconcerting shadow or brightness distribution changes. The purpose of the matching tests was to find what level of fluorescent lighting was selected by the subjects to match a controlled level of filament lighting, on a criterion of "equal comfort." This criterion was not discussed with the subjects, nor was it explained to them in any way at all. They were only told that the control knob provided could be used by them to make the alternative lighting (the fluorescent) brighter, and that they were to adjust it to give "equal comfort." The subjects were allowed to take their own time to achieve a match. Each subject made two independent matches at illumination levels of 6 and 11 lm/ft^2, and both daylight and fluorescent lamps were used during the course of the experiments.

The mean level of the fluorescent lighting when matched for equal comfort was 4.2 per cent. above that of the filament lighting. This difference is statistically significant at the 5 per cent. level, but scarcely measurable instrumentally under the conditions of the experiment. Although discriminable visually, it is too small to be likely to have any other physiological effect. It is thus reasonable to assert that the subjects interpreted "equal comfort" to mean approximately "equal lumens per square foot of illumination."

In a further series of experiments three groups of subjects doing mainly clerical and similar office work were exposed daily to either filament or fluorescent lighting over a period of four months. During this period it was necessary to use artificial lighting throughout the hours of duty each day in the building used for the experiment. Each group consisted of 10 subjects working in three adjacent rooms under one of three different lighting conditions: filament lighting, fluorescent lighting on a.c. (i.e., with flicker present), and fluorescent lighting on d.c., having the same spectral distribution of light energy but without flicker.

The subjects carried out their normal daily work routine interspersed with various tests of performance, mainly of a clerical nature, and a performance test which was a multiple choice task involving visual discrimination of Landolt rings projected on to a screen from a film strip. The subjects were tested within the first hour of duty and again within the last hour of duty in a room away from the working site in which standard environmental conditions (including illumination) were maintained. The illumination on the working plane in each office was 12 ± 2 lm/ft^2. The experiments were terminated when it was considered that the amount of daylight had risen to such a value as to mask the effects of the artificial lighting.

A number of preliminary tests were used in the first few weeks of the experiment. In the last nine weeks the tests consisted mainly of the visual acuity performance test. The experiments were designed to permit the measurement of difference in performance time, in errors and in decrement of performance, between the morning and the afternoon test sessions. In addition, ocular muscle balance readings were made with the Maddox wing test instrument. Eyesight tests were carried out on all subjects to ensure that their vision was up to the standard previously mentioned.

The results of this long-term study showed that there was no significant difference between the performance under filament and fluorescent lighting whether on a.c. or d.c. supply (i.e., with or without flicker at 100c/sec.). A borderline significant difference was actually found for one test (error rate) between the two groups exposed to filament lighting and fluorescent lighting on a.c. It was considered unwise to attach much importance to this finding, especially in view of the other results, which showed no differences, and it has been discounted, therefore, in the final assessment of the results of these experiments.

Conclusion

It may be concluded from these experiments that the type of illuminant (filament or fluorescent) does not affect performance. The experiments have further shown that the 100 c/s. flicker element of fluorescent lighting also does not affect performance. Inasmuch as the tests used correlate positively with performance at clerical and similar tasks, clerical or fine clerical work, involving visual acuity of a few minutes of arc, appears to be carried out as effectively in fluorescent lighting as in filament lighting of equal illumination level. The conclusions are valid within the range of illumination levels studied, namely, 5-20 lm/ft^2. There were no explicit colour or colour-matching studies involved in these experiments, and no attempt was made to study colour rendering as a separate factor.

Throughout these experiments no significant changes in ocular muscle balance were observed, correlated with type of illuminant, test procedure, the daily work task or time of day.

The author acknowledges the permission of the Engineer-in-Chief of the Post Office to make use of the results of the experiments described in the paper.

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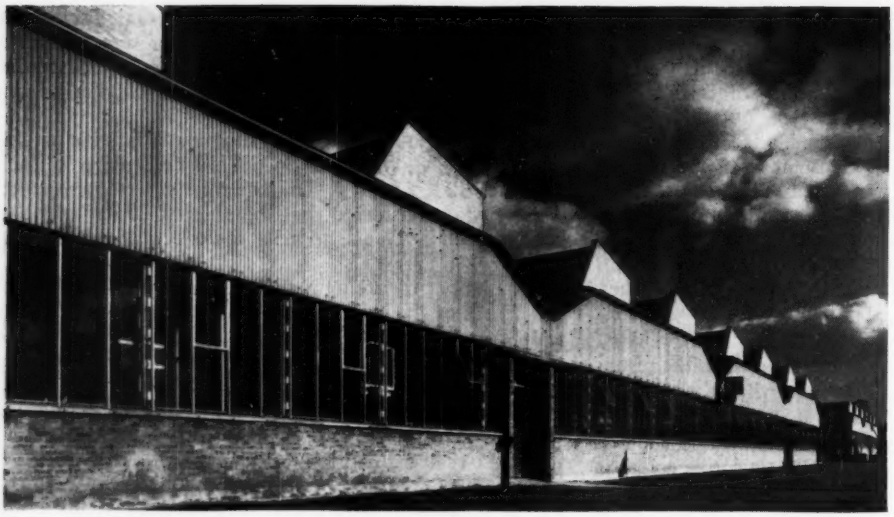


The main production block, showing the profile of the B.R.S.-type roof-lights. The subsidiary production block is on the far right.

Factory at Harlow New Town

Design by the Harlow Development Corporation (architect-planner, Frederick Gibberd, C.B.E., F.R.I.B.A., M.T.P.I.; executive architect, Victor Hamnett, B.Sc., A.R.I.B.A., A.M.T.P.I., A.R.I.C.S.); main contractor, Wilson Lovatt and Son, Ltd.; lighting fittings supplied by The General Electric Company, Ltd.

IN the construction of the rectifier factory of Standard Telephones and Cables, Ltd.—the largest factory in the Templefields industrial estate of Harlow New Town—three different structural systems were used, each having been regarded as the most logical choice under the particular circumstances. These three structural solutions have, in turn, necessitated the adoption of three different lighting arrangements—for both daylighting and artificial lighting.

The factory occupies an 8½-acre site, with a 140-yard frontage to the south side of Edinburgh-way—the east-west spine road that cuts through the estate. There are three main buildings: the main production block, where the rectifier components are manufactured and assembled; a subsidiary production block, where rectifier equipment is manufactured and assembled; and a two-storey office block, with laboratories on the ground floor and a restaurant on the first floor. The office block is 40 ft. deep and, since it therefore requires natural lighting from both sides, it stands apart from the other buildings.

The larger part of the main production block has a frame and roof of high-tensile steel, with lattice-type main beams at 24-ft. centres supported by columns at 60-ft. centres. These beams comprise a cranked lattice compression member, prestressed by three high-tensile steel bars, and provide one of the first examples of the use of prestressed steelwork in this country.

High-tensile steel was chosen to make possible wide spacing of the stanchions, with consequent flexibility of plant layout, without using a large weight of steel. The resulting structure is complex, and maintenance costs may be high, but the weight of structural steel, excluding the framing for the monitor rooflights, is only 3.4 lb./sq. ft. of floor area.

The roof covering consists of channel-reinforced wood-wool slabs, supported on steel secondary beams, with ½-in. cement screed, and built-up bituminous roofing.

The central part of the main production area is the processing shop, and, since it is essential that this area should be free from ledges that could harbour dust, it is covered by a series of seven shell-concrete barrel vaults, each spanning 30 ft. and supported by reinforced concrete columns at 49-ft. centres. These columns are linked by stiffening beams following the profile of the shells. The roof of this area is covered with three-ply felt roofing, and is insulated on the underside with ½-in. insulation board.

The subsidiary production block was commenced later than the main block, at a time when structural steel was more readily available. Welded mild steel has been used, providing a clean and simple structure comprising 16 in. x 6 in. rolled steel joists welded together to form Portal frames, each spanning 60 ft., at 24-ft. centres. This framework supports a roof-covering similar to that over the main production block.

.....it's three systems of artificial lighting

APART from the area covered by concrete barrel vaults, daylighting throughout the production areas is by monitor rooflights based on the Building Research Station's design. These are asymmetrical in section, so that the area of glazing facing north is greater than that facing south. This ensures that most of the light comes from the north, but provides a small component of south light to minimise glare. There are rows of lantern-type rooflights along the apexes of the barrel vaults, the concrete of which is pierced also by other rooflights, midway between the lantern lights and the edge beams.

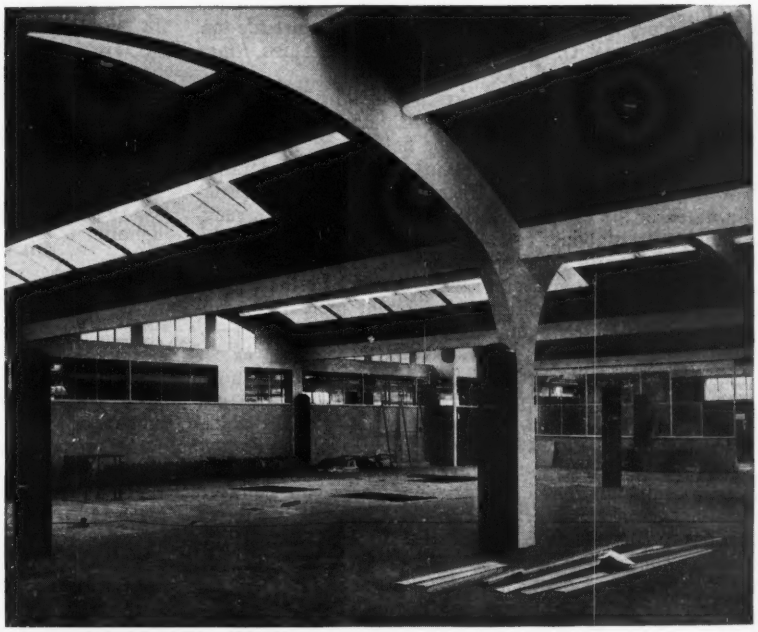
In addition there is continuous glazing in the external walls, including opening lights, to enable the workers in the plant to see out from time to time.

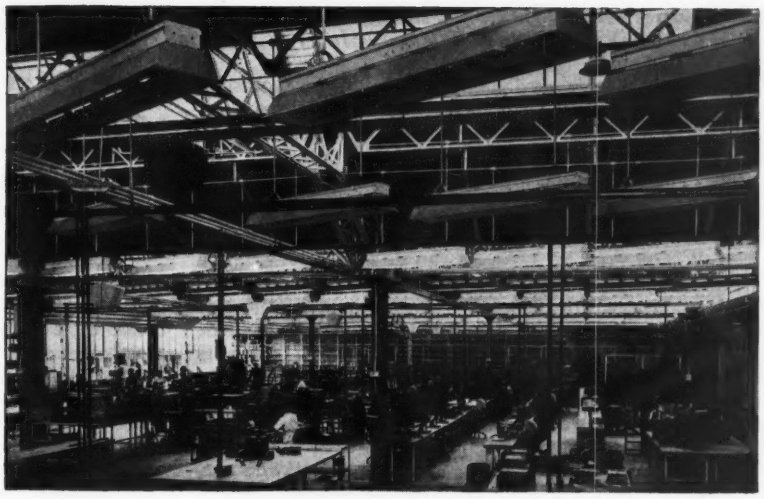
Artificial lighting in the main production block is provided by diagonally arranged rows of vitreous-enamelled trough fittings, each housing two 80-watt fluorescent lamps. The fittings are suspended from the roof structure and provide 30-40 lm/ft². In the subsidiary production area similar fittings are fixed to rows of continuous trunking.

An illumination level of 30 lm/ft² is provided in the air-conditioned processing shop by continuous rows of specially designed ceiling fittings with no dust-collecting ledges. These fittings each house two 80-watt fluorescent lamps and have diffusing covers of opal "Perspex." A removable plate in the side of each fitting gives access to the starting gear, without disturbing either the diffusing covers or the lamps.

In the bay of the assembly shop devoted to heavy equipment, the need for an overhead crane resulted in this area having a high roof. It is lit, therefore, by special fittings, each housing one 400-watt high-pressure mercury lamp and one 1,000-watt tungsten lamp. The fittings have anodised aluminium reflectors.

Laboratories and offices are lit by ceiling-mounted fluorescent fittings with reeded "Perspex" diffusers; the entrance hall by circular tungsten fittings recessed into the ceiling. The works canteen, used also for social events, is provided with two installations: for normal use it is lit by 500-watt tungsten lamps in decorative pendant fittings, giving an average illumination level of 7 lm/ft². Extra lighting for special occasions is provided by ceiling fittings, with plastic louvred covers, each housing six 80-watt fluorescent lamps, which raise the illumination level to 25 lm/ft².





Top: Continuous lines of fluorescent fittings with "Perspex" diffusing covers in the barrel-vaulted processing shop. Bottom: Pairs of 80-watt fluorescent lamps in vitreous-enamelled trough fittings arranged in diagonal rows in the main production block.

Lighting Abstracts

LAMPS AND FITTINGS

621.327.43

319. Fluorescent luminaires for refrigerated areas.
T. SUMMERS, Jr., *Illum. Engng.*, **51,** 261-265 (*March*, 1956).

Fluorescent lighting for refrigerated storerooms has the particular advantage of a smaller amount of generated heat. Reliable starting and good light output at the lower temperatures are, however, essential. Tests with a number of fluorescent luminaires in a storeroom maintained at 0 deg. F. showed that these requirements could be achieved provided that ordinary lamps were enclosed in close-fitting clear plastic tubes or in a larger plastic enclosure or a 1,000 milliamp. "rapid start" lamp was used. A 28 per cent. reduction in generated heat load was achieved by replacing incandescent with fluorescent lamps. P. P.

612.843.367

320. Mercury and filament lighting can be comfortable too.
E. A. LINDSAY, Q. D. DOBRAS and D. R. PHILLIPS, *Illum. Engng.*, **51,** 269-273 (*March*, 1956).

Contemporary industrial fluorescent lighting incorporates such comfort factors as increased shielding, a greater component of upward flux and lighter finishes on the outside of the luminaire. A number of installations incorporating these factors are described. These factors can now be incorporated in the design of mercury and incandescent tungsten luminaires giving correspondingly glare-free installations. An experimental aluminium reflector is described and its comfort rating is related to those of old-type luminaires. The economics of a number of different mercury, incandescent and fluorescent luminaires are compared. P. P.

LIGHTING

321. Physiological bases for rational lighting. 612.84
Y. LE GRAND, *Lux*, **24,** 6-7 (*Jan.-Feb.*, 1956). *In French.*

A brief review of modern work and conclusions on necessary illumination and work on Codes, on comfort, including glare, flicker, etc., and on fatigue. It is stressed that it is often difficult to produce figures for some of these factors. The author notes that "the old battle of fluorescence is over," and quotes recent work establishing that the fluorescent lamp is not responsible for special effects of fatigue and discomfort. J. M. W.

322. Louvres for sunlight. 628.92
J. ESCHER-DESRIVIERES. *Lux*, **24,** 8-10 (*Jan.-Feb.*, 1956). *In French.*

Describes a new daylighting system for a workshop having a ceiling with pyramidical cells and pyramidical lanterns above them, glazed with "Thermolux." The internal effect is that of a louvred ceiling. It is compared with an installation of artificially lighted but discreet cells at the Galeries Lafayette. J. M. W.

323. Daylighting designs with overhangs. 628.92
J. W. GRIFFITH, W. J. ARNER and E. W. CONOVER, *Illum. Eng.*, **51,** 241-246 (*March*, 1956).

Measurements are reported of the daylight illumination obtained in a one-twelfth scale model room with a single side window shaded by solid and louvred overhangs (canopies) either extending horizontally or sloping downwards from the window head. The effects of sunlight and of ground reflections were taken into account. The Modified Lumen Method of Daylighting Design has been adapted for the prediction of the daylighting in side-lit rooms with continuous overhangs and a worked example is given. P. P.

324. Foot-candles for the forgotten man. 612.843.6
S. K. GUTH and A. A. EASTMAN, *Illum. Engng.*, **51,** 251-255 (*March*, 1956).

Visual data are often derived as the average of the response of a number of observers. The average value, however, represents a condition which will be inadequate for half the observers. The significance of this is demonstrated in a study of the levels of illumination required by 40 observers in a visibility test where the variation in the individual levels was about 10:1. A plea is made that the requirements of all the observers taking part in a visual study should be given consideration. P. P.

628.92

325. Acrylic louvre wall panels for classroom daylighting
E. M. LINFORTH, *Illum. Engng.*, **51,** 231-236 (*March*, 1956).

Introduces a new window material consisting of a transparent acrylic sheet bent into a series of horizontal louvres of zig-zag section. The upper surface of each louvre is opaque and has a high reflection factor finish. Sheets are made with 20 deg. and 45 deg. angles of cut-off. Extensive measurements of the daylighting in a half-scale room with windows of this material are reported. Ground reflections are shown to make an important contribution to the interior lighting. P. P.

628.9

326. Artificial lighting in Switzerland: Résumé of progress during the last 30 years.
J. GUANTER, *Bull. Assoc. Suisse Elect.*, **47,** 289-296 (*March* 31, 1956). *In French.*

The author first traces the progress of lighting considered as part of the central station load. From 1912 to 1948 there was a continuous fall in the percentage of the total load attributable to lighting, but this was due to the growth of other applications of electricity. The lighting load is then analysed according to type of consumer. Home lighting accounts for 36 per cent., industrial lighting 26 per cent. and street lighting 12 per cent. From time to time publicity measures have been taken to encourage the use of electricity for lighting. In this work an important part has been played by the Lighting Bureau founded in 1930. The cathedral at Berne was first floodlighted in 1928 and many other notable buildings are now illuminated. Recently a football field near Zurich had been equipped for playing after dark. The Swiss National Illumination Committee has issued codes of interior lighting and street lighting as well as a lighting manual. J. W. T. W.

628.972

327. The pleasant and the comfortable in lighting.
W. ARNDT and D. FISCHER, *Lichttechnik*, **8,** 99-103 (*March*, 1956). *In German.*

Good lighting means more than conformity with a Code of Practice. There are many other factors, more or less intangible, which determine whether or not an installation is comfortable or produces a sensation of pleasantness. In most cases such a factor depends on the avoidance of extremes in some quality which contributes to pleasantness only if present to a certain extent. The upper and lower limits of the range within which it should lie can only be determined by collective opinion. The authors show photographs of certain installations and analyse these to illustrate their remarks. J. W. T. W.

A New Sodium Lamp*

This article describes a new design of sodium vapour lamp for street lighting and general service which, while interchangeable with existing European lamps, does not require a Dewar flask jacket and gives an improved performance. Extensive field trials on the new lamp have been successfully completed

By E. H. NELSON and S. A. R. RIGDEN

The passage of an electric current through the vapour of sodium metal causes the sodium atoms to emit the well-known yellow light characteristic of sodium and consisting almost entirely of two spectral lines at 5890 and 5896 A.U. The problem confronting the lamp engineer is to effect this transformation of electrical into visible energy in a practicable lamp at the highest possible efficiency. If the transformation could be made at 100 per cent. efficiency a light source of about 500 lm./w. would be realised. Present light sources, of course, fall far below this figure, and the reason for this lies in the impossibility of achieving ideal conditions in practice.

The design of a successful sodium discharge lamp presents to the lamp engineer many complex problems which have been the subject of an extensive literature(1). Before describing the new lamp it will be useful to review briefly the processes in the discharge giving rise to these problems and the solutions offered by the design of lamp now in use in England and on the Continent.

(1) Discharge Processes

(1.1) *Effect of Sodium Vapour Pressure and Current Density of the Arc*

The two main factors which determine the efficiency of sodium lamps are the pressure of the sodium vapour and the current density in the vapour, i.e., the current per unit area of cross-section of the discharge. For highest transformation efficiency the current density must be low and the sodium vapour pressure must be at an optimum value which is related in a complex way to the current density and to the dimensions of the discharge tube.

Fig. 1 shows the relationship between current density and luminous efficiency in a sodium vapour discharge for various values of sodium vapour pressure. It will be seen that, over the range considered, luminous efficiency increases rapidly as the current density is reduced and the vapour pressure increased.

In the laboratory it is possible to heat the discharge tube in an oven to a temperature at which the sodium vapour pressure is an optimum and then pass a small current through the discharge tube so that the current density is kept very low. In this manner, and disregarding the energy supplied by the oven as heat to the lamp, luminous efficiencies of several hundred lumens per watt have been obtained(2), but the current is so low that the light output from the source is insufficient for practical purposes.

It will be appreciated that if, in the experiment described above, the oven is removed, the pressure of the sodium vapour will fall, as will the luminous efficiency of the discharge. If now the current through the lamp is increased to the point where the vapour pressure is maintained at the optimum value, both light output and efficiency will increase, although the increase in efficiency will be small because of the increase in current density.

Thus it will be seen that the problem of designing an efficient sodium vapour lamp resolves itself into reconciling two opposing factors: the need to keep the current density low to achieve a high efficiency, and the need to keep it high enough to maintain the required sodium vapour pressure and to obtain a high light output. A fundamental requirement of good sodium lamp design is that the heat generated by the discharge must be utilised efficiently to vaporise the sodium.

(1.2) *Gas Filling*

In addition to the problem of effecting a suitable compromise between current density and sodium vapour pressure there are, as in most discharge devices, special problems related to the initiation of the discharge. At ordinary ambient temperatures the vapour pressure of sodium is much too low to enable a discharge to pass at ordinary voltages. Consequently, a practical sodium lamp contains a quantity of a permanent gas, the purpose

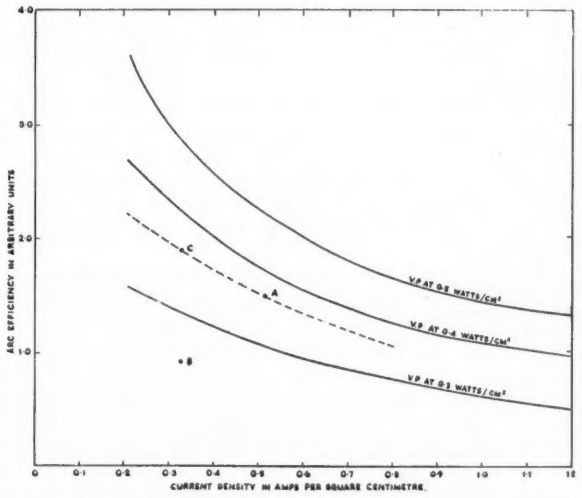


Fig. 1. Relative arc efficiency of a sodium vapour discharge as a function of current density at various vapour pressures (V.P.).

* Communication from the Staff of the Research Laboratories of The General Electric Company Limited, Wembley, England.

of which is to enable the discharge to start at a reasonable voltage and to provide sufficient heating to vaporise the sodium. Neon gas performs these functions admirably, and to obtain a still lower starting voltage it is usually mixed with a small amount of argon.

(2) Present Design of Sodium Lamp

In England and on the Continent four ratings of sodium lamps are in use for general lighting purposes: 45-watt, 60-watt, 85-watt and 140-watt[3]. These lamps are so similar in design that it will be sufficient to discuss the 140-watt rating shown in Fig. 2. This operates from a leakage reactance transformer having an open-circuit voltage of about 470.

The need for a high degree of thermal insulation is met in this lamp by the use of a Dewar flask jacket. This is similar in construction to the familiar "Thermos" flask, but without internal silvering. The arc tube of the lamp is inserted in the Dewar flask so that it is surrounded by the flask, except at the open end, which is closed by a well-fitting ceramic cap. Many suggestions[4] have been put forward for increasing the effectiveness of this method of heat conservation. These involve multiple walled Dewar flasks, localised reflecting surfaces or selectively transparent coatings which allow sodium radiation to pass while absorbing all other radiation. None of these methods has come into common use.

The luminous efficiency of the lamp shown in Fig. 2 is 73 lm./w. at 100 hours, and the average efficiency during a 4,000-hour life is 65 lm./w. A high average luminous output during life is of the greatest importance to the lighting engineer and a high initial efficiency, unless associated with a correspondingly high average-through-life value, is undesirable.

(2.1) *Sodium Resistant Glass*

An important factor determining lumen maintenance is the rate of discoloration of the glass tube by the ionised sodium vapour. This depends on the nature of the glass and the pressure of the vapour. To reduce glass attack the inside surface of the arc tube is coated with a thin film of a glass which is highly resistant to attack by hot sodium vapour. The protective glass most widely used in the past is of sodium borate composition. Even with this special glass some discoloration occurs owing to the absorption of metallic sodium by the thin layer of protective glass. Due to this and to the movement, or migration, of the globules of sodium in the tube, the luminous efficiency falls off at the rate of about 4 per cent. per 1,000 hours during the greater part of the life of the lamp.

Sodium migration is due almost entirely to thermal diffusion effects resulting from unavoidable temperature differences along the arc tube. In the course of time the globules of sodium metal, initially well distributed throughout the tube, tend to concentrate in one of the limbs of the U tube, with a resultant loss in light output. Various proposals have been made for overcoming sodium migration, but no completely successful method has yet been found.

Other glasses are known which effectively resist sodium attack[5], and because these glasses show less discoloration than the sodium borate glass they are potentially capable of giving better efficiency maintenance throughout the life of the lamp. This is not achieved in practice, however, because of sodium migration. In practice it has been found that the sodium absorbed in the sodium borate glass provides a supply of sodium vapour even when all the visible globules have migrated to another part of the tube. This reservoir action of the less resistant glass tends to compensate for the migration losses. It seems unlikely that the potential gains in light output from glasses which show no or only little discoloration will be realised until a satisfactory solution to the problem of thermal migration of sodium is found.

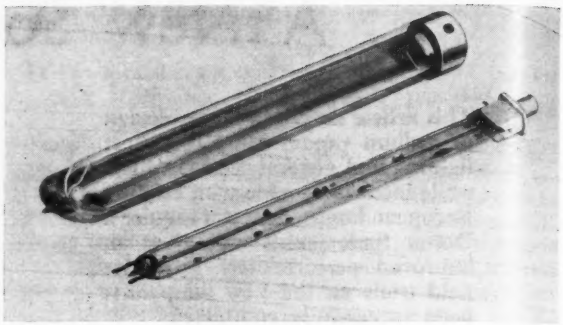


Fig. 2. Conventional 140-watt sodium lamp with Dewar jacket.

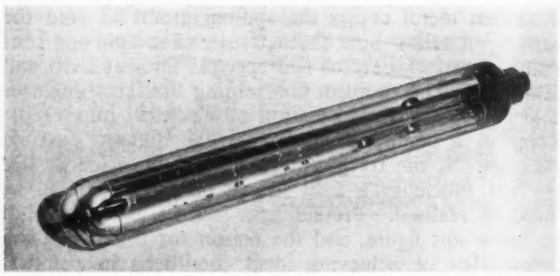


Fig. 3. New integral type 140-watt sodium lamp.

(3) The New Lamp

Many attempts have been made in the past to manufacture sodium lamps with simple evacuated jackets, but no great success has been achieved, partly because of the difficulty of obtaining, by ordinary lamp production methods, a sufficiently good jacket vacuum which will not deteriorate during the life of the lamp. The Dewar flask has provided an acceptable answer to the problem in the past, because it was found easier to obtain and maintain the required high degree of vacuum in a device free from metal parts. Another feature of the Dewar flask is that its inner wall acts as a heat reflector which is missing from the simple jacketed lamp.

In Fig. 3 is shown a recently developed form of lamp[6] in which the separate Dewar flask is replaced by a simple single-walled evacuated glass jacket which greatly improves robustness and serviceability. In the new lamp vacuum deterioration is avoided by careful pumping of the space between the outer jacket and discharge tube, coupled with the use of a layer of barium metal

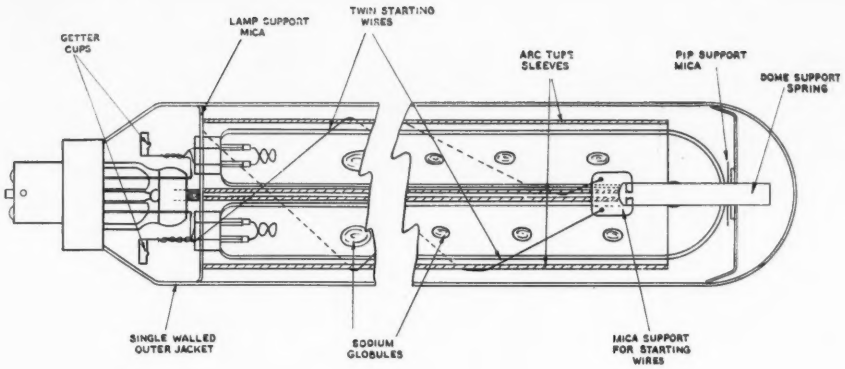


Fig. 4. Sectional diagram of the new 140-watt lamp.

which ensures that any gas liberated during the life of the lamp is absorbed as rapidly as it is evolved. The problem has been to devise an exhaust schedule which is economic and which will ensure a high degree of vacuum within the lamp for a minimum of 4,000 hours at a glass temperature of up to 300 deg. C.

An important feature of the design of the new lamp is the closely fitting sleeves, which serve as an efficient means of heat absorption and reflection. As these sleeves completely surround each limb of the lamp, they also tend to even out temperature inequalities arising from convection currents inside the discharge tube. They do not, however, deal with the localised temperature differences along the length of the discharge envelope which give rise to sodium migration discussed earlier. This improved method of heat conservation results in a substantial increase in luminous efficiency.

The new design of lamp, therefore, embodies two features tending to improve the conservation of heat from the discharge. Firstly, the discharge tube is contained in a highly evacuated enclosure which prevents heat conduction and convection losses from the arc tube. Secondly, each limb of the discharge tube is closely surrounded by screens which absorb infra-red energy from the discharge, some of which is subsequently re-radiated back as heat to the discharge tube.

Fig. 4 shows a sectional diagram of the new 140-watt lamp. The light source is the familiar U shape, but because of the better thermal insulation it is possible to make it in larger bore tubing compared with the equivalent Dewar-jacketed lamp. Since this change in tube diameter has very little effect on the electrical characteristics of the lamp, the lamp wattage is unchanged, but the current density is appreciably decreased.

Referring to Fig. 1, point A represents the operating condition for a normal Dewar-jacketed lamp. It can be seen that if a larger inner were operated without its sleeves in a Dewar jacket, the arc efficiency would be less than for a normal lamp, as indicated by point B, but when operating with sleeves and in an evacuated outer jacket, the arc efficiency is raised to a level indicated by C. The sodium vapour pressure is the same as in the normal Dewar type lamp, but the larger tube diameter permits the discharge to run at a lower current density with a resulting gain in luminous efficiency.

In its present form, as shown in Figs. 3 and 4, the new lamp is interchangeable both mechanically and electrically with the corresponding Dewar type. The requirement of interchangeability imposes some limits on the maximum efficiency it is possible to reach, but lamps using the new construction and the same type of glass as the normal Dewar lamp have given an average-through-life efficiency 10 per cent. higher than the normal Dewar lamp. If the sodium migration problems associated with the more resistant glasses can be overcome, it is expected that a gain in performance over the normal Dewar lamp of about 20 per cent. will be possible.

(4) Advantages of New Design

In addition to the improved luminous performance the following additional advantages of an integral design should be noted.

The starting voltage of the new lamp is lower (by some 20-50 volts) than the voltage normally required by Dewar-type lamps. This may be attributed largely to the increase in arc tube diameter, but the double starting wire shown in Fig. 3 is also of some assistance in this respect. A more important feature, however, is that the starting voltage is likely to remain at a low level for a longer time. The use of a larger lamp enables a greater volume of gas filling to be used without altering the required mixture and pressure. There is, therefore, a reduced probability of premature starting voltage failure from gas clean-up.

It is well known that the starting voltage of a sodium lamp is liable to increase under conditions of high humidity. In Dewar-jacketed lamps this difficulty is sometimes overcome by the use of small silica gel driers inserted into the Dewar which absorb atmospheric moisture during " off " periods and are regenerated during the operation of the lamp[7]. Another method which is sometimes adopted is to coat the outside of the discharge tube with a silicone varnish, which disperses the conducting moisture film into discreet droplets. In the new design the highly evacuated outer jacket which encloses the arc tube eliminates any possibility of humidity effects and ensures a high degree of constancy under all service conditions.

In the Dewar-jacketed lamp normal switching on and off results in a succession of expansions and contractions of the air enclosed in the jacket which result in opaque dust films settling within the Dewar. Loss of light from

this obscuration may be considerable in industrial areas. Moreover, the Dewar flask itself has a definite life, usually of the order of 10,000 hours, and, even assuming it is replaced after this period, it introduces a factor into the lamp performance which is difficult to control. For these reasons and because lamp replacement is simplified, the elimination of the Dewar flask is likely to be welcomed by the street lighting engineer.

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(1) Blok, L., Philips Tech. Rev., **1**, 87 (1936).
Dorgelo, E. G., and Bouma, P. J., Philips Tech. Rev. **2**, 253 (1937).
Uyterhoven, W., Philips Tech. Rev., **3**, 157, 197 (1938).
(2) Druyvestein, M. J., Phys. Zeitschrift, **33**, 822 (1932).
(3) Edwards, E. F., Electrical Review, p. 403 (Feb., 1953).
(4) British Patent Nos. 372154 and 389726.
(5) British Patent No. 675594.
(6) Patent Application Nos. 2517/54 and 20306/54
(7) British Patent No. 465337.

NEW PRODUCTS

Polystyrene

Styrene Products Ltd. announce that their "Erinoid" range of polystyrene can now be supplied with light resistant qualities.

Polystyrene is a thermoplastic which is ideal for the production of mass produced articles by the injection moulding and extrusion techniques; it has several properties which are of great interest to the lighting industry. Unpigmented, it is completely crystal clear, it is exceedingly light in weight (specific gravity 1.06), its electrical properties are excellent, and lastly it is the lowest priced rigid and highly transparent thermoplastic obtainable. Mouldings have a lustrous surface finish and can be made in a range of colours from crystal clear through transparent colours and translucent opals to complete opaques.

Until recently two factors limited the use of this material for the lighting industry, namely, the tendency for slight yellowing to occur on exposure to light, and the maintenance of a static charge on the moulding which causes dust collection.

The stabilisation to light now announced is of importance in crystal clear and opal shades, such colours being the most popular in the lighting industry. Tests have indicated that whereas an unstabilised crystal clear or opal colour begins to yellow after about 8 months, and over a longer period gradually becomes brown, the stabilised varieties experience no change for at least 3½ years; it is doubtful if yellowing will occur over even longer periods. This light stabilised quality can be given to the general purpose, heat resistant and high molecular weight grades, all of which have their specific uses in the lighting industry.

The second problem of static charge has, to a great extent, being overcome by the availability of chemical solutions which can be utilised to surface coat mouldings and extrusions. The technique is to dip the moulding in this solution for approximately 30 seconds immediately after moulding, the heat of the article being sufficient to dry off the solvent quickly and leave a protective film. Results on moulded fittings treated in this way indicate that for at least one year and probably considerably longer, the dust patterns associated with an article bearing a static charge are eliminated. If mouldings are subsequently washed from time to time in water containing detergent this in turn will impart to the moulding a temporary destaticising effect which can be maintained by redipping in solution after cleansing. No elaborate equipment is required for this process.

Another new development is an opal pearl pigmentation which helps to diffuse the light whilst permitting maximum light transmission.

In connection with these materials some interesting work has been carried out by Tube Lamination and Engineering Limited, in conjunction with the Ministry of Works; this work culminated in the patent "Clipluve" louvre unit (Fig. 1) which is a one-piece moulding ready to fit direct to a fluorescent lamp. It requires no metal clips or other attachments which might cause shadow or obstruct the free passage of light. The light loss due to screening the direct view of the lamp within 30 deg. is only of the order of 12 per cent. whilst the downward lighting component remains unrestricted. The use of these louvre units with the newly introduced reflector fluorescent lamp, forms an efficient lighting fitting of

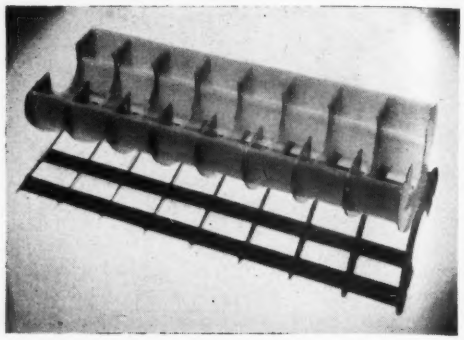

Fig. 1

pleasing appearance at low cost. In addition they can be built up to form multi-lamp fittings, or by adaption can be effectively used to cover continuous lengths of cold cathode tubing on ceilings.

Louvred panels of the cellular or "eggcrate" variety (Fig. 2) are also being produced by injection moulding, and are available in various forms. These moulded sections can be assembled together so that any size of panel can be made up. This louvre gives a general lighting efficiency of 80 per cent.

The combination of moulded louvres with extruded poly-

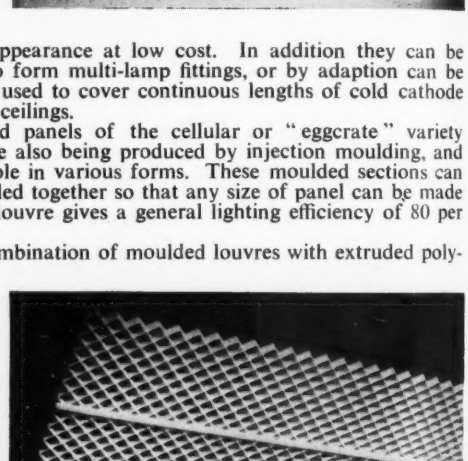

Fig. 2

styrene edges has permitted the production of lighting panels, which can be made up to any required size, so as to be conveniently installed in existing frames, or to hang on existing ceiling cross members. Complete ceilings can be fitted with these louvre tiles. Extruded polystyrene sections are now being produced which can be utilised as side panels in existing lighting frames, or as complete shaded diffuser screens to cover fluorescent lamps from end to end

When once a particular design has been decided upon and the appropriate tool made, polystyrene can be extruded in lengths comparatively cheaply. These extruded fittings are usually produced in a high molecular weight heat resistant grade of polystyrene, which imparts a general 50 per cent. increase in strength over normal polystyrene, and a permanent heat distortion figure of 85 deg. C.

An Illuminating Engineer's Slide-Rule

By WILLIAM W. CALDER, A.M.I.Struc.E.

The calculation of illumination usually involves reference to separately published tables for room index, utilisation factor and lamp lumens and a certain amount of laborious arithmetic. This article describes a slide rule which does the calculation quickly, giving an approximate answer which is near enough for most purposes.

This slide-rule was devised for the rapid solution of the common equations relating to interior lighting design. There are two faces; the topmost scale in each figure is the front of the rule. Fig. 1 is a simplified diagram and Fig. 2 shows all the graduations and is suitable for cutting out to make an actual slide rule. The front scales provide the means for calculating the size of lamps for various illumination levels. The back scales form a proportional device to show the "room index," together with the related "coefficients of utilisation" (or utilisation factors) for direct, semi-direct, and indirect lighting fittings.

The slide-rule is assembled after the fashion of the "Duplex" rule where the stock carries a common slide, and has scales on both faces of the body and the stock; there is no need for a cursor on this rule.

The back of the rule has four series of graduations. These are, "Room Index," "Length," "Width," and "Height." Knowing the dimensions of the space to be illuminated, the width on the slide is set against the height on the stock and we read room indices against lengths. The linear dimensions are all in feet; the height scale is the vertical distance from the working plane to the lighting fitting. The room index corresponds approximately to the room index which may be found by reference to the E.L.M.A. Handbook "Illumination Design for Interiors" issued by the Lighting Service Bureau, or to one of the standard text books. If the index letters are reversed, i.e., J for A, D for G, etc., then the rearrangement corresponds with American documents relating to lighting design.

The room index needs to be related to the utilisation factor. These factors, or coefficients, are dependent on the type of fitting and the reflection surfaces of the room. It will be seen that a guide to the numerical value of these factors is indicated on the rule. Three rows of figures occur above the room indices; these are the factors for three types when used in rooms whose ceilings and walls have reflection values of 70 and 50 per cent. respectively. If the most adverse conditions were to prevail, with reflection values of 30 and 10 per cent. for ceilings and walls respectively, the coefficients of utilisation would drop to about two-thirds of the value of A, and about nine-tenths of the value of J.

The lower row of figures shows utilisation factors when using direct fittings which provide 70 per cent. downwards light. The middle row shows the factors for fittings which provide about 55 per cent. downward and 15 per cent. upward light. The upper row, and smallest numerical values, relates to indirect fittings and trough types which give all, or nearly all, of their light output in the upward direction without sharp directional control of the light. These are good average figures and, provided they are wisely interpreted, form a useful guide to the probable illumination made available by the various types of fittings. It should, however, be appreciated that there are fittings which could be classified under these headings, or descriptions, but have a performance which falls short of the numerical values attributed the fittings on the rule. If there is any doubt as to correct value for the coefficient of utilisation then reference should be made to the maker's catalogue. At this stage it would be prudent to add another caution on the standard of maintenance for the fittings once they are in service. It will be seen later that the maintenance factor is taken as 0.8, but inattention to cleaning fittings can quite easily halve the light output even from the best-designed fittings.

The rear face of the rule is concerned solely with the determination of the room index, and from this, the utilisation factor. The numerical value of this factor is applied to the front of the rule before the sizes or spacing of the various fittings can be determined.

The front face of the rule consists of four logarithmic scales arranged to solve the standard equation

$$F = \frac{E_{av}\, A}{0.80 v}$$

with one setting of the slide. In this equation, the symbols are:

F = Lumens needed from each lamp,
E_{av} = Average illumination in lm/ft² needed in service,
A = Area of working plane illuminated per lamp in sq. ft.
v = Coefficient of utilisation.

The value 0.80 in the divisor is the maintenance factor, and this recognises the deterioration of reflection or transmission of light from dust-coated fittings. In dust-laden atmospheres where the fittings may not receive adequate cleaning, it might be prudent to double the value of F. (This is equal to a reduction of the maintenance factor from 0.8 to 0.4.)

The general equation, as shown above, is not in a suitable form for solving in one setting of logarithmic scales. Applying the equation to an ordinary slide-rule, three settings would be needed for the solution. By rearranging the equation in the shape $\frac{F}{A} = \frac{E_{av}}{0.8v}$ one setting is sufficient to establish one related series of proportions which satisfy the equation. If values of F are set against A then this setting will show equal proportions of E_{av} against v. The maintenance factor is a constant and is

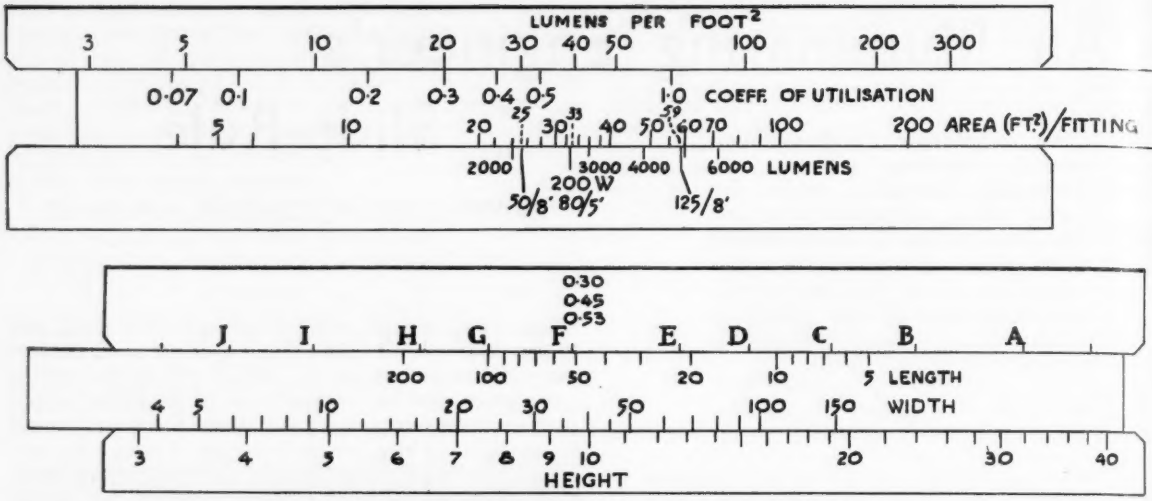

Fig. 1. Arrangement of scales on front (upper) and back (lower).

allowed for in the calibration of the scale of v. In this way the maintenance factor disappears from the rule but its effect is still operative in the calculations. We may ignore the maintenance factor now except for the special circumstances of dust-laden atmospheres when a correction would be applied, as previously stated, by adjusting the value of the flux from each lamp.

The front scales will show accurately a wide variety of satisfactory values for any given proportion of F and A with one setting of the slide and eliminate the tedium of simple yet tiresome arithmetic of illumination calculations.

The uppermost scale, graduated from 3 to 3,000, is the range of average lumens per square foot, and corresponds to E_{av} in the general equation. The uppermost slide scale is graduated in values of the coefficient of utilisation; the range is from 0.07 to 1.00, and will cover any condition likely to be met with in practice.

If a known value of average illumination is set against a known value for the coefficient of utilisation, then we have placed the scales on the slide and stock in a position which will show equal ratios of lumens per lamp and area per lamp. If we know any two values of E_{av} and v, or of A and F, then by one setting to bring one pair of known values coincidental, a whole range of agreeable values are found, opposite to each other on the other pair of scales. (This is demonstrated in an example.)

The lower slide scale is graduated from 4 to 400 and is the range of areas in square feet per fitting. The lower stock scale has a range of from 200 to 20,000 lumens. To avoid a bunching of figures on this scale, the numbers represent 1,000 lumens, i.e., 0.2 to 20. This is the scale of F, the lumens required from each lamp. Underneath the graduations there are two rows of figures and a series of gauge marks for a variety of lamps, the upper and lower row are for incandescent and fluorescent lamps respectively. These gauge masks were selected from "Illumination Design for Interiors." The numbers refer to the wattage and are the average lumens throughout the life of the lamp. (15 and 25 are single coil pearl lamps; pearl coiled-coil lamps have been selected for the gauge marks from 40 to 100 watts; thereafter the lamps are single coil pearl to 150 watt, and clear to 500 watt.)

"Natural" colour lamps have been selected for the fluorescent lamp gauge marks, and these are located at the value of the average lumens throughout life. Thus the figure 40/4 refers to a 4 ft. lamp rated at 40-watt with an average output of 1,520 lumens. This lamp will, of course, give 1,800 lumens during its first 100 hours of service and fall away to about 1,280 lumens during its final hours of usefulness. Gauge marks were not provided for the various types of electrical discharge lamps since they call for more special consideration, both in selection and fitting. The main purpose in devising this slide-rule was to provide a quick and portable means of calculating the more common size of lamps for interior illumination.

Examples

The front scales, reading downwards, are referred to as E, upper stock scale; v, upper slide scale; A, lower slide scale; F, lower stock scale.

The rear scales, reading downwards, are referred to as Cv upper stock scale; L, upper slide scale; W, lower slide scale; H, lower stock scale.

Example 1 (illustrated in Fig. 1)

An office is 65 ft. long by 20 ft. wide, the ceiling height is 13 ft., and the height from the working plane to the luminaire is 7 ft. Select alternative lamp sizes, using indirect fittings with incandescent and fluorescent lamps, to give an average illumination of 20 lm/ft².

Set 20 (W) against 7 (H) and read Room Index "F" opposite 65 (L) on Cv. The utilisation factor for this index, using indirect fittings, is 0.30.

Turn the rule over to the front scales and set 0.30 (v) against 20 (E). Refer now to the (A) and (F) scales, and do not disturb the setting of the slide. It will be seen that one 200-watt incandescent lamp, or one 5-ft. 80-watt fluorescent lamp, on the (F) scale is opposite 33 sq. ft. (A). Alternatively one 8-ft. 125-watt fluorescent lamp (F) could be used for every 59 sq. ft. (A), or one 5-ft. 80-watt tube (F) for every 25 sq. ft. (A).

The alternative solutions, or the variations that are shown to each size of room, is one of the good features of this slide-rule. In this example the engineer or architect can select the most appropriate solution, but this feature does not limit the scope of the rule, as a further example shows.

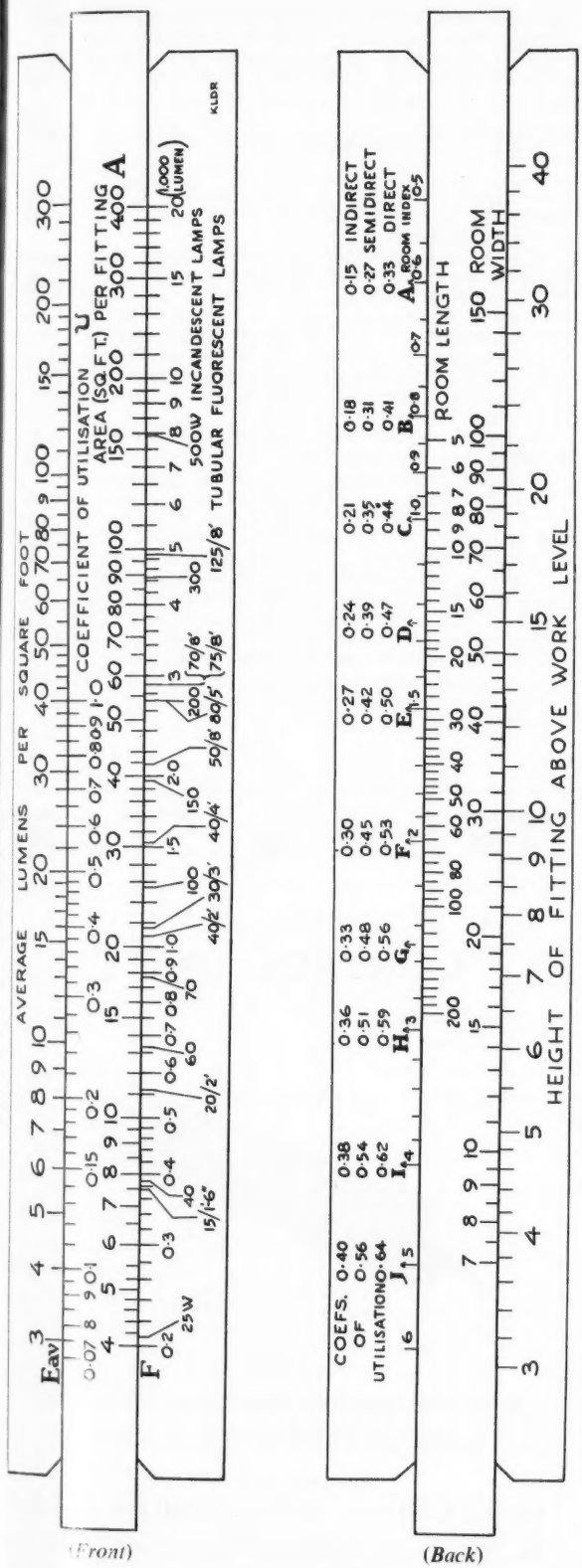

Fig. 2. Complete scales suitable for mounting as a slide rule.

Example 2

A hall measures 100 ft. long by 25 ft. wide and is illuminated by eight 100-watt incandescent lamps mounted 12 ft. 6 in. above the floor in reflector-type direct fittings. It is required to establish the average standard of lighting on a plane 3 ft. above the floor, and to propose a new scheme of lighting which will at least double the present level of illumination.*

To establish the existing average illumination, set 25 (W) against 9.5 (H) and opposite 100 (L) read Room Index "F" ($C\upsilon$). For direct fittings, the utilisation factor is 0.53.

We may use the front lower scales (A and F) for dividing the floor area by the number of fittings so long as the decimal point is wisely interpreted. Against the area 2,500 (F) set 8 (A) and opposite 10 (A) read the area per fitting 312.5 sq. ft. on (F). (This is a case of using the scales in the manner of an ordinary slide-rule.)

Against 100-watt incandescent lamp gauge mark (F) set 312.5 (A). The stock now projects so far to the left that the graduation of 0.53 on the scale (υ), coefficient of utilisation, is beyond the scale of average lumens (E). The solution to this condition is to set 31.25 (A) against 100 watts (F); opposite 0.53 (υ) read 17.2 (E). This value must be divided by 10, since we have already divided the floor area by 10. The true value for the average illumination is therefore 1.72.

If direct fittings were to be employed for the new scheme, and an average of 7 lm/ft^2 is advocated, then we may employ 100-watt incandescent lamps every 76 sq. ft., or 150-watt incandescent lamps every 137 sq. ft. This was found by setting 0.53 (υ) opposite 7 (E). Referring to the lower scales, we obtain the results 76 and 137 sq. ft. per fitting on (A) opposite 100 and 150 watts respectively on (F).

The number of 150-watt fittings can be found by setting 137 (A) against 2,500 (F), and opposite 10 (A), read 210, the correct number of fittings being 21, the number which would have appeared opposite 1 if the scale of (A) were continued to unity.

To derive the greatest benefit from this slide-rule the user should make himself thoroughly familiar with the instrument. This is done, as with any slide-rule, by making up problems and then working them out by means of the slide-rule. Once the slide-rule is completely understood, and the user thoroughly familiar with it, he will find that he has acquired a facility which greatly reduces the calculations for interior lighting design.

Making the Slide-Rule

The material for the stock is cut to size, taking the dimensions from the illustration. The inside edges of the two parts which make the stock are grooved and the slide is tongued to fit these grooves. For this reason the material for the slide is cut about an eighth of an inch wider than is shown on the illustration to allow for the tongues being taken out of the solid. When the slide is fitted to the stock, the three faces, or strips, should have the same width as that of the three strips shown on the illustration; it should also be noted that the strip width (F) is common with ($C\upsilon$). The slide is also made about a quarter of an inch longer than the stock.

Thin metal brackets are cut sufficiently wide to take

* It should be appreciated that the level of illumination in this example is extremely low, but is chosen to demonstrate the scope of the slide-rule.

two one-sixteenth-inch-diameter wire rivets in the length of the stock, and to be sufficiently rigid to hold the stock parts parallel to each other. The inside faces of these brackets are filed off in the way of the slide to provide a clearance when manipulating the slide and to prevent any mechanical damage to the slide's scale surfaces.

The scales as printed can be cut from the page and glued on to the assembled rule and varnished. Once the varnish has dried the paper slide scales can be separated from the stock scales by cutting down their length with a sharp knife. This will ensure that the upper and lower stock scales are correctly registered.

Alternatively, it is possible to detach the six scale strips from the page, and mount them separately before assembling the slide-rule. The scales can be aligned by drawing a registration mark or line before cutting them, or by assembling them in the following order. Mount the front scales first and use the slide scales to register the stock scales. 40 (E_{av}) and 1 (v) are coincident, then 6 (A) and 300 (F) should also be made coincident. On the rear of the rule, the scale (H) is then mounted. 30 (W) is brought coincident with 10 (H), and on this setting the scale (Cv) is mounted. The graduation 1.5 below the index "E" should be in alignment with 28 (L).

Acknowledgment

When this slide-rule was first proposed, Mr. J. G. Holmes, technical director of Holophane, Ltd., suggested some refinements in the disposition of the scales on the back of the rule. His proposals have done much to keep the Room Indices in reasonable agreement with other published data, and while there may be some small deviation of the Indices between the slide-rule and other tabular data, the differences are sufficiently small that they may safely be neglected.

Correspondence

The Calculation of Room Index

Dear Sir,—The slide rule described by Mr. Calder in this issue is based on an approximate but not strictly accurate formula for Room Index and it may be of interest to record the formula and the degree of error. It must be clearly stated that the rule is sufficiently accurate for the majority of calculations of Room Index.

The original Room Ratio of Harrison and Anderson for square rooms was given by the formula :—

$$\text{Room Ratio} = \text{Side/Twice Height} = S/2.h$$

and they proposed a device for rectangular rooms which may be represented by the formula :—

$$\text{Room Ratio} = \frac{\text{Twice width + length}}{6 \times \text{height}} = \frac{2.w + l}{6.h}$$

This was convenient for mental arithmetic but not very accurate, and the C.I.E. in Zürich last year recommended the following formula for international adoption :—

$$\text{Room Ratio} = \frac{\text{width} \times \text{length}}{\text{height} \times \text{sum of width and length}} = \frac{w \times l}{h \times (w + l)}$$

Neither of these formulae for rectangular rooms is convenient for calculation on a slide rule because addition and multiplication are both involved.

If the conversion from a rectangular room to the equivalent square room is calculated as a weighted geometric mean, rather than as a weighted arithmetic mean or a harmonic mean as in the two formulae above, the calculation could be performed readily on a slide rule. A little trial and error showed that a suitable formula would be :—

$$\text{Room Ratio} = \sqrt[3]{\frac{w^2 \times l}{1.96 \times h}}$$

This is quite unsuitable for mental arithmetic but it is convenient for a slide rule and the scales in Mr. Calder's rule have been based on it.

The intervals between the letter indices in the usual Room Index table correspond to steps of about 23 per cent. in the numerical value of the Room Ratio. The original Harrison and Anderson formula was about 11 per cent. error for rectangular rooms in which the length was three times the width, and 40 per cent. for a length of five times the width. The approximate formula given above gives errors of less than 5 per cent. between square rooms and 5 : 1 rectangular rooms.

It should be emphasised that the present formula is not proposed as a substitute for the C.I.E. formula but is only a convenient approximation for slide rule purposes.

Finally, it may be noted that the usual relation between the Room Index letter and the Room Ratio is not strictly that given in W. R. Stevens' book "Principles of Lighting." It is indicated in that book, as it has been elsewhere, that, for example, a Room Index of D corresponds to a Room Ratio of 1.25, and a Room Index E corresponds to a Room Ratio of 1.5. In the original calculations of Room Indices, however, it seems that the letter D was used for Room Ratios between 1.25 and 1.5 and E for Room Ratios of 1.5 to 2.0, so that the figures in Stevens' book represent the lower limit of the range to be ascribed to each Room Index letter.

London. J. G. HOLMES.

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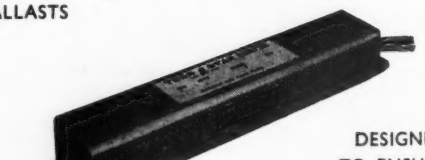

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I.E.S. Dow Prize Competition for Essays on

How I Look at Lighting Engineering

First Prize	}	C. Stuart
Second Prize	}	R. W. Taylor
Third Prize	-	Derek Phillips
Commendation	-	E. Harrison Jones

Report of Assessors

We recommend that awards should be made as follows:— (1) First and Second prizes equally divided between entries 2 and 6. (2) Third prize to entry No. 8. (3) Commendation to entry No. 3.

There were eight entries for the competition. Although the standard varied considerably, the better entries were sufficiently meritorious to demand very careful consideration in order to award the first prize. The approaches made to the subject by the various candidates were devious, and this, of course, added to the difficulty of decision. We have decided, after carefully weighing each essay against the specific conditions of entry, to award the first and second prizes jointly to Numbers 2 and 6.

These essays represent very different methods of dealing with the subject. Candidate No. 2 shows the wide range of problems with terms, perhaps rather from the point of view of the research man, although in sufficient detail to show a substantial knowledge of his subject. He makes some sensible comments on the training which a lighting engineer should undergo. His essay is good.

Candidate No. 6 takes the somewhat smaller, but nevertheless important, range of commercial and industrial lighting by way of example, and works out his analysis with common sense and skill. He discusses many practical problems in a sound manner, giving the impression of one intimately associated with the day-to-day tasks of engineering light. His style of writing is rather less smooth than that of Candidate No. 2, but is suited to his type of analysis and argument.

Candidates Nos. 3 and 8 deal with the subject primarily as designers of decorative lighting, with particular emphasis on architectural values. The third prize is awarded to No. 8 because of his better style of writing, and because of his wider and better-planned argument. His presentation was attractive. Candidate No. 3 also presented his material well, particularly his photographs and diagrams, but his forceful and interesting attack was unduly weakened by too little consideration for other aspects of the subject. He is awarded a commendation.

The remaining entries, although interesting, are not recommended for commendation. Generally they suffered from lack of conciseness or too shallow an argument. Nevertheless, their entries were well worth making, and all participants in the competition are to be congratulated on their efforts.

In any such competition as this the final awards do depend greatly on the personal preference of the assessors. It is nevertheless interesting to note that the two assessors independently agreed on the four candidates who deserved the main awards. The final places were settled by subsequent discussion.

HOWARD LONG.
W. R. STEVENS.

Summaries of Joint Winners of 1st and 2nd Prizes

C. STUART

The examples and illustrations in this essay are actual experiences of and schemes designed by the writer.

In illuminating engineering artistic intuition and aesthetic considerations will conflict with purely materialistic and efficiency achievements.

Lighting engineers must accept limits within which they shall work—the activity—the degree of contrast—the colour —cost, etc. To-day the lighting engineer is an electrical engineer who specialises in lighting. This condition will disappear when the industry institutes "apprenticeships" or "training schemes."

The architect must realise that there are physical limits, give early warning of what is expected, be prepared to accept the advice of experience and be able to give a picture of the effects he requires.

The engineer is a man of rigid rules and exact method. Thus, he can best approach every problem psychologically, before attempting to consider the engineering requirements. Take an example such as a restaurant where the creation of an atmosphere is more important than luminous intensity. The lighting can be used to create a general binding factor, e.g., low level overall illumination. Now must be added a brighter pool of light for each table. Many and varied are the ways to achieve this.

Ideally the lighting engineer should collaborate with at least one other profession—architect, consulting engineer or interior decorator, but in the majority of schemes he is expected to work alone. Thus he should acquaint himself with some knowledge of architecture together with the tenets of colour sense.

The practising lighting engineer's experience will range between the extremes of engineering efficiency and pure art: from open-yard lighting to cathedral lighting. To almost all these must be added the necessity of creating the correct atmosphere.

Consider the following installation. A large department store acquired single storey garage premises next door. The suspended "lighting ceiling" chosen evened out the differences in the heights and types of roof. Colour lighting in small alcoves provided for shadow-box display. The photograph shows a section of the finished result.

Care should be taken to relate cost to achievement. A lighting installation must be regarded as a capital investment. In most cases the wiring is fixed for a period.

Flexibility is partly provided by trunking. In a conduit installation far greater flexibility can be given by the use

Example of a suspended ceiling to hide variations in the structural ceiling.

of stretcher wires with fittings suspended from the stretcher wires or the conduit.

The question of cost brings us to maintenance. This must be made easy but is apt to be an after-thought. However, maintenance costs money. On completion of an installation, the lighting engineer should issue a maintenance chart. Fittings should be chosen for ease of relamping and removal of reflectors.

The planning will be varied, but having decided the illumination required, the design begins and should be by a combination of the lumen method and point by point method. The result must be vetted by "Brightness Engineering."

For economy and to prevent the monotonous flatness of high intensity schemes, the ratio of working machine area (A) to the remaining floor area (B) is calculated. The working illumination is used for "A" and not less than 60 per cent. of "A" for "B." After this, the fittings are positioned by the point to point method.

Generally it is sufficient to apply "Brightness Engineering" to the near finished design. In particularly fine work it is advisable to decide the brightness and proceed with the scheme in order. In a scheme to reveal beauty or to enhance architectural design, "Brightness Engineering" is most important. The most important formulae are given in J. M. Waldram's paper "Studies in Interior Lighting."

The types of lighting fittings are without number. The greater the variety, the greater is the engineer's choice as he will largely have to depend on stock fittings.

Perhaps where the lighting engineer fails himself most is in his lack of "public relations" with his clients. He cannot shirk the fact that he must accept responsibility and having considered the facts give clear-cut answers.

Good lighting from both aesthetic and efficiency viewpoints can be achieved. A growing development must be cultivated of the constant balance between efficiency and art. Good engineering requires that the highest possible efficiency be maintained while achieving these factors of psychology and comfort. This means a knowledge of the mechanism of the eye and constant study of the responses of the eye to various conditions.

It would be wrong to look 20 years ahead. It is the immediate future which must concern us. We are now entering a period of stability for the development of application techniques. In no past period has there been the variation of sources, nor profusion of colour available to those who practise lighting.

Probably, even more than in architecture can lighting engineering bring together the exact sciences and artistic conceptions. Whether this be sooner or later will depend on whether the lighting industry as a whole takes the adventure boldly to-day or to-morrow.

The lighting engineer is and requires to be a man of many parts and arts. He is in the modern manner and of the future and it is for him as an individual to add dignity to the profession by his skill, ingenuity and integrity.

R. W. TAYLOR

My impressions of lighting engineering have been gathered, first as an amateur and then as a practitioner. In this essay I have considered various jobs, techniques, advances and possible developments. Nearly every person in nearly every activity requires light. The lighting engineer is needed to assess the situation, to apply knowledge, and to do the job in the best possible way. He is also concerned with the tools and instruments used or with the units that produce or modify the light. The term lighting engineer indicates that the subject is a branch of engineering.

The training of the lighting engineer must cover a wide field; science, engineering, some artistic sympathy, the rudiments of architecture, drawing, sketching, and the mechanics of the eye. The City and Guilds of London Institute Examination courses take only two years. This could profitably be extended to four or five years and cover the following additional subjects: mathematics, physics (with emphasis on light, optics and electricity), ophthalmology. A good professional man will continue to learn until he retires.

A few examples are considered to see what is required from the practising light engineer.

One of the simplest jobs is to provide light to perform a given task. This may be to play football, after dusk, before spectators at a sports stadium. The installation has to enable the players to perform as they would in daylight. The spectators must be able to watch in comfort and without glare. All faces of the ball have to be lighted so that it appears spherical. It must be possible to follow the flight of the ball.

The difficulties may be structural, they may be financial, or they may be from small causes such as the peculiar reflection characteristics of grass turf. The solution may involve small groups of lights at high levels or long rows at low levels. When the installation has been made, it may be found that the spectacle is all the richer for being played at night.

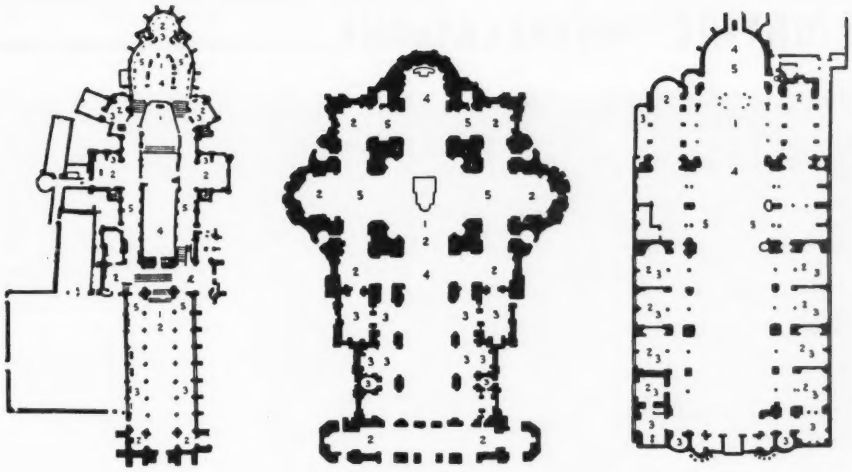
Another task is lighting in and around an aerodrome. At about 3,000 ft. from the landing point and at about 200 ft. up the pilot must land using his eyes only. In other conditions than fine weather and daylight, assistance is required from various lighting fittings. For locating the airfield and for simple landing aids beacons are used. For locating the design problems are similar to those of lighthouses. For a landing aid the beacon has to direct a coloured beam from the ground. More positive indication is achieved if the landing beam is flanked by similar beams of different colours. Greater conspicuity can be achieved by flashing the beams.

The best landing aids are undoubtedly patterns of lights on the ground. The first glimpse of the visual pattern must be clear and unambiguous. The main objectives are for the pilot to sense the ground plane, the horizon, his direction of approach, and to avoid over or undershooting his landing point. One of the most effective systems consists of transverse lines through which runs a centre line.

The runway lights often define the runway edges or run

Ground plans of cathedrals:

(a) Gothic (Canterbury)
(b) Renaissance (St. Peters)
(c) Romanesque (Westminster)



(a) *(b)* *(c)*

parallel to them. They can be recessed into the ground or they can be mounted on stalks. Taxi lights are basically low power runway lights. The apron is usually floodlighted. There must be no light directed above the horizontal.

One of the tasks of the lighting engineer is that of designing fittings and installations for street lighting. The sodium vapour lamps seem to be the most popular. The main factor in reversing this situation may be the improved colour rendering of the mercury vapour type by means of fluorescent powders.

An interesting problem was that of lighting tree lined side streets. Side streets are lighted primarily for the pedestrian. Hence it is desirable to reveal the pavement, front gardens and house fronts, as much as the street, and the installation should be pleasing. For this investigation several lanterns were designed and constructed and tested in suitable streets. The results of these experiments were a new type of lantern and a lot more information about spacing and mounting heights.

When lighting interiors such as homes or public buildings, other problems can arise. This is particularly true of the lighting of religious buildings. In addition to the main lighting task, there are considerations of tradition, history, aesthetics and architecture. Of paramount importance in this field are tact and common sense. The consultant is not always in the best position to decide what is or is not important, particularly in non-functional jobs.

Cathedrals are a special problem (see illustration); there are the larger spaces (1), smaller spaces (2), and the smallest of spaces (3), the choirs and clergy stalls (4) and the long stretches (5) are needed for processions. Having lighted each section according to its use it is necessary to ensure that the fittings match the styles.

The most popular method of designing an installation depends on estimating the field flux to arrive at the illumination. However, brightness is a realistic criterion. Apparent brightness is an even more sensible criterion to consider. The amount of light present is not the only factor. Form and texture must be revealed. The question of emphasis is more difficult to deal with.

Everything must be subjected to constructive criticism. Does one measure intensity, flux or illumination when concerned with a fitting? Do we require brightness or illumination when concerned with the field? It depends on the job. If the job is an airfield, a road or a coalmine, then the task is objective. If, however, the job is a theatre, dance hall or a home, then the task is subjective.

There is much work to be done to tabulate data, to interpret statistics, to try to find some methodical way of dealing with sensation and to improve our means of measuring stimulus.

I have been trying to show that I look on lighting engineering as a wide and ever expanding field of activity scarcely out of its infancy. The lighting engineer needs many talents. He who is concerned with the field as a whole, and who is in increasng demand, must be more widely educated and he must spend his life in widening his horizons and intensifying his knowledge.

Situations

Vacant

Ekco-Ensign Electric Ltd. have vacancy in their London Office for LIGHTING ENGINEER. He should be well educated and conversant with modern lighting methods. Apply Senior Lighting Engineer, 45, Essex Street, W.C.2.

Lighting fitting manufacturers of national repute require DESIGNER-DRAUGHTSMAN or DRAUGHTSMAN, and JUNIOR. Work is varied and mainly specially designed. Applications to Box 920, giving full details.

DESIGNER, with experience of street lighting fittings, required by electrical manufacturing company in Manchester. Pension scheme, canteen facilities, five-day week. Full particulars of experience and salary required to Box No. 922.

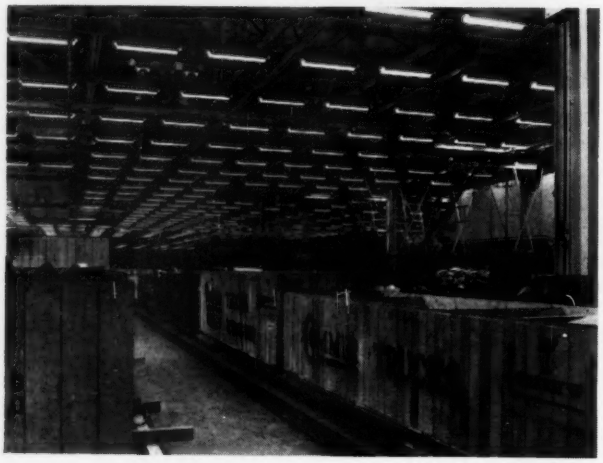
LIGHTING SALES ENGINEERS experienced in commercial and industrial modern practice, technically qualified with sales experience for London areas, are required for further sales expansion of highly successful and developing equipment. Please reply giving full details of age, experience and salary required to Box No. 923.

ILLUMINATING ENGINEER, capable of preparing lighting schemes and estimates for modern emporiums and commercial buildings. Applicants should have experience in dealing with large and individually designed light installation. Experience in the design of the special light fittings and the general knowledge of the electrical contracting industry would be an advantage. The job offers scope for applicants with initiative, and in the first place you should apply, stating technical qualifications and experience, to Mr. G. K. Medlock, A.M.I.Mech.E., Chief Engineer, C.W.S. Limited, Engineering Office, Hanover Street, Corporation Street, Manchester 4.

Philips Electrical Limited have a vacancy for a DRAUGHTSMAN in the Lighting Fittings Design Department of their London Head Office. Some drawing office experience in fluorescent lighting fittings or similar light industrial equipment is necessary. A knowledge of sheet metal work, electrical installation and wiring is desirable. Please reply to the Personnel Officer, Century House, Shaftesbury Avenue, London, W.C.2.

LIGHTING ENGINEER required for old-establshed firm of lighting fittings manufacturers in the S.W.1 area. Experience of industrial, commercial and decorative lighting required. Send details of age and qualifications to Box 921. Own staff advised.

LIGHTING INSTALLATIONS



Factory of Commer Cars, Ltd., Dunstable.

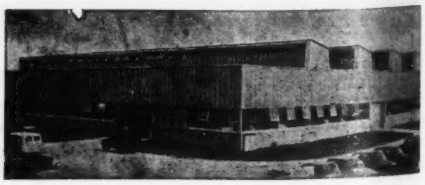
The new assembly plant of Commer Cars, Ltd. (*left*), is 720 ft. long and 330 ft. wide. Continuous trunking—17,000 ft. of it—has been fixed to the steel roof trusses, with four rows to each 90 ft. bay. There are 1,600 twin-lamp 80-watt fluorescent fittings suspended from the trunking. Clear headroom in the assembly shops is 21 ft. and the average illumination level at the working plane is 25 lm/ft². Control gear is mounted in trays which fit into the trunking; it is of a special design to allow the lamps to operate directly from the 450V supply. (Contractors, Rashleigh Phipps and Co., Ltd.; "Mazda" trunking by The A.E.I. Lamp and Lighting Co., Ltd.)

Factory for J. Stone and Co. (Deptford) Ltd., Crawley, Sussex.

The continuous trunking used in the new factory of J. Stone and Co. (Deptford), Ltd. (*right*), is made of H-section steel. It has two upper compartments, one for the lighting supply cables and one for low-voltage wiring for telephones, impulse clocks, etc. Control gear for the fluorescent fittings suspended from the trunking is housed in the lower compartment, on detachable sliding trays. The illumination level is 28-30 lm/ft², and has proved sufficient to dispense with nearly all local lighting for the machines. (Contractors, Drake and Gorham (Contractors), Ltd.; "Atlas" trunking by Thorn Electrical Industries, Ltd.)

Workshops of the Rover Company, Ltd., Solihull, Warwickshire.

Continuous trunking has also been used in the new Rover Car workshops. The general lighting consists of 30 runs of trunking equipped with 448 open-ended, vitreous-enamelled reflectors, each housing 5 ft. 80-watt fluorescent lamps with "instant-start" gear. Along the main assembly lines (*left*), in addition to the general lighting, there are two rows of trunking, set at right angles to the main trunking 8 ft. above floor level. This gives very high illumination levels, up to 60 lm/ft² on the centre of the car bonnets. Elsewhere, the illumination level is between 24 and 32 lm/ft², depending on the spacing of the fittings on the trunking. (Electrical contractors, Lee, Beesley and Co., Ltd.; trunking by The General Electric Co., Ltd.)



Workshop of Craven Bros. (Manchester), Ltd., at Stockport.

The high precision work involved in the use of gear-cutting machines necessitates the maintenance of a uniform ambient temperature. This new workshop (*left*) is air-conditioned to provide a constant air temperature of 68 deg. F., with a variation of only one degree. To assist the temperature control, projections from walls and ceiling have been minimised and the 21 trough lighting fittings, each housing two 80-watt fluorescent lamps, are recessed. These fittings (supplied by G.E.C.) provide 14 lm/ft². at floor level, the dimensions of the workshop being 150 ft. x 50 ft. x 38 ft. 6 in. high.

Chemical Plant at the Beeston Works of Boots Pure Drug Co., Ltd.

In the manufacture of Cortisone, several highly inflammable solvents are used. The whole of this plant (*right*) is, therefore, designated as a hazardous area. In addition, the fittings had to be such that men working on the raised platforms would not be troubled by glare, while their position had to be arranged to minimise shadows cast by the intricate plant. The lighting installation was designed and carried out by Boots' own engineering staff, using Holophane prismatic flameproof fittings housing 300-watt tungsten lamps, suspended on a 10 ft. x 12 ft. 6 in. grid. from the roat trusses. The illumination level, both at 3 ft. 6 in. above floor level and of the upper platform levels, is between 18 and 20 lm/ft².

Margarine Factory of Van den Berghs and Jurgens, Ltd., at Purfleet, Essex.

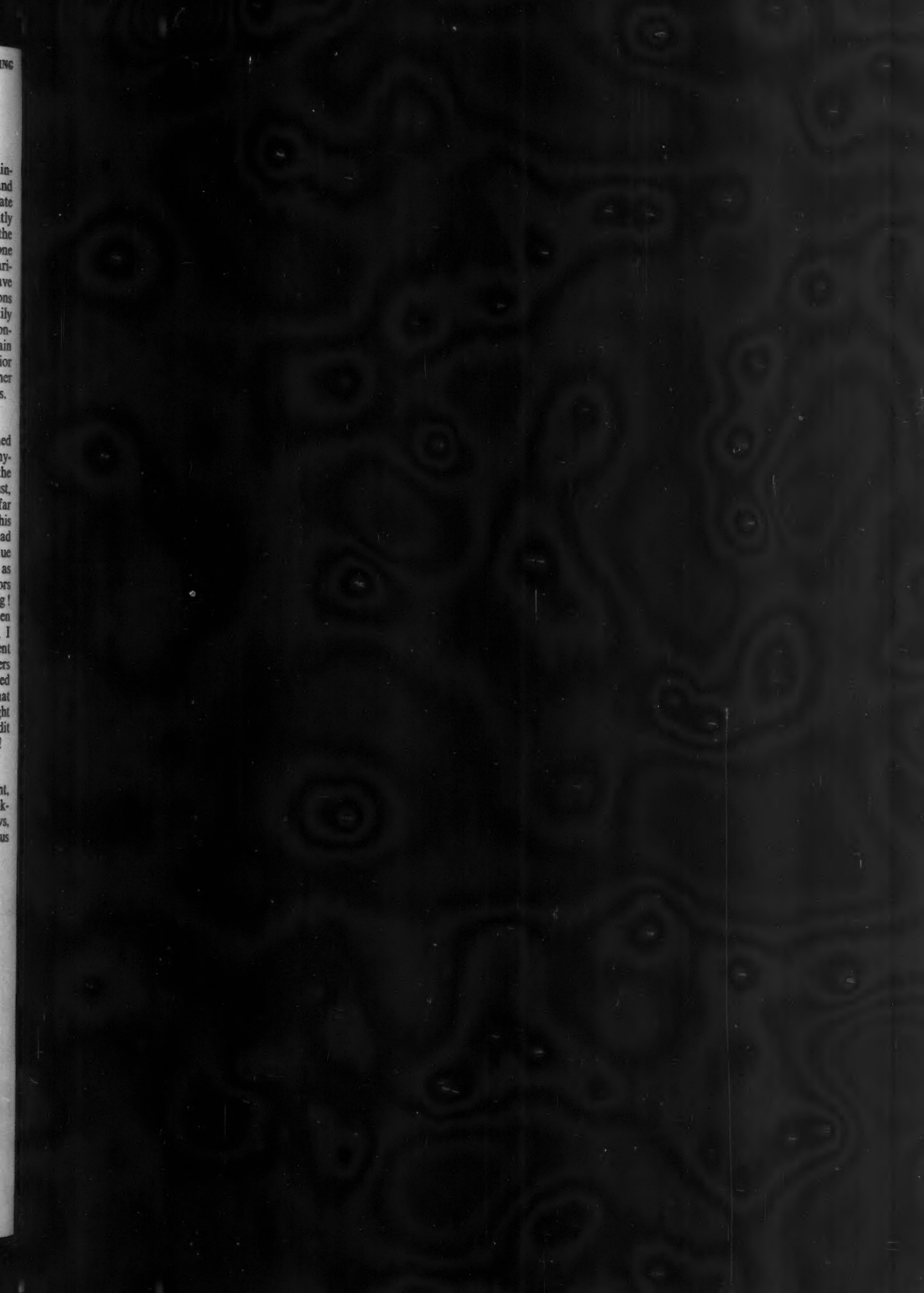
In order to provide a dust-free atmosphere and to assist in the regulation of the temperature in the plant, a false ceiling has been installed. Continuous trunking (supplied by G.E.C.) is suspended through the ceiling by conduit, which is connected to the main roof structure above. Fixed to the trunking are continuous rows of fluorescent fittings, giving an illumination level of 20 lm/ft². (Installation by Wm. Steward and Co., Ltd.)

POSTSCRIPT By "Lumeritas"

LAST MONTH I referred to a suggestion that misleading street lighting may have been partly responsible for the tragic road accident, at Fence, near Sheffield, in which all nine members of a wedding party were killed. Since then the inquest has been held, and it is reassuring to find that the doubt as to the suitability of the lighting seems to have been dispelled. The coroner is reported as saying that "speed and alcohol" contributed to the accident, but he is not reported as making any comment on the street lighting. The inference from Press reports is that the "case" against the street lighting was either not proceeded with or not proven, but it would be interesting to know more about local conditions—both the topography of the road and the system of lighting—and to know whether the lighting is now completely exonerated in the minds of those to whom it was originally suspect. Some readers of this journal must know the road in question and the actual site of the accident—which I believe is a recognised "danger spot": what are their views on the lighting?

THE familiar indirect system of lighting the escalators at London's Underground stations seems gradually to be giving place to the direct method, with fluorescent lamps mounted close to the roof of the inclined shaft and the lamp axis parallel to the escalator axis. There is no doubt that where this change has been made greater visibility has resulted. This is a welcome gain. The indirect escalator lighting may be glare-free, but this is not very comforting when one cannot see very confidently because the illumination is illiberal. Escalators are not accident-free and they need to be well lighted, especially during periods when people are crowding on to them. Perhaps the new installations would be better if the lamps were fitted with transverse louvres, although I do not feel this is a point of great importance.

THIS is the holiday season, when many of us will be taking a "rest"—or at any rate having a change—by the sea or in the country before settling down to another lengthy spell of bread-winning. Spring is almost forgotten and also, perhaps, is the cleaning traditionally associated with it. Maybe, however, the perennial maintenance work upon which the amateur painter and decorator embarks with mixed feelings—to renovate where mere cleaning doesn't suffice—has been so recently completed that we are still "sore" about some of the causes of interior "wear and tear." Unfortunately, one of these causes is lighting—but only because it is invariably accompanied by heating. If only we could have light sources which give us light without other radiations those areas of ceiling and upper walls now too hastily yellowed or browned by the impact of dust-laden convection currents, set up by light sources, would remain unsullied for longer periods. But, alas, our interior decorations would still be all too quickly marred by other areas of discoloration due to house-warming appliances.

THAT I am one of the "holiday"-makers mentioned in the preceding paragraph is indicated by the accompanying optimistic sketch. The poet Byron wrote that the English summer begins in July and ends in August, and a good many of us may think that he wasn't far wrong! There may be a little poetic licence about his statement, but anyone who shares the fairly widespread popular notion that the badness of our summers is due to atomic bombs and thermo-nuclear explosions may as well be reminded that before the advent of such horrors our summers had a nasty habit of being disappointing! However, I am pleased to report that Old Sol has given me facilities for my "study" of sunlight: in fact, I have—unintentionally—almost repeated an experiment described by the famous Newton in one of his letters whereby he acquired a crop of after-images that plagued him for days! I have also come to the conclusion that adaptation after prolonged exposure to very bright light takes longer as one grows older, but I claim no credit for this discovery which others have made before me!

TURNING, for a few words, from bright to dim light, a baby born by candlelight during an electricity breakdown has been named Candella. As the spelling shows, the child is not to be confused with the unit of luminous intensity!